Ministry of the Environment
of the Czech Republic

MINERAL COMMODITY SUMMARIES OF THE CZECH REPUBLIC 2022

STATISTICAL DATA TO 2021

(Data deadline: October 31, 2022)

Czech Geological Survey

November 2022

Compiled by:
Jaromír Starý
Ivo Sitenský
Dalibor Mašek
Zbyněk Gabriel
Matěj Němec
Tereza Hodková
Mirko Vaněček
Jaroslav Novák
Pavel Kavina

Typesetting:
Oleg Man

Graphic design:
Oleg Man
Dalibor Mašek
Budoš Volák
Renata Kachlíková

secretar@geology.cz
www.geology.cz

CONTENTS

INTRODUCTION

The yearbook “Mineral commodity summaries of the Czech Republic” is the only publication that informs the Czech and foreign interested public about the state and use of the domestic mineral base in the world context and within the legal framework of mineral exploration and mine production in our country through economics, environmental protection to resources and mining of mineral commodities in our country in historical development and including association with geology.

This year, the yearbook Mineral Commodity Summaries of the Czech Republic is being published for the twenty-ninths times in its history. It was published and distributed on behalf of the Ministry of Economy until 1996, and on behalf of the Ministry of the Environment from 1997 till present.

After the dissolution of the state-funded organization Czech Geological Survey – Geofond on 31 December 2011, the semi-budgetary organization Czech Geological Survey was charged with compiling the publication *Mineral Commodity Summaries of the Czech Republic*. With isolated interruption in 2011, the Ministry of the Environment commissions the compilation and distribution of the publication, by increasing the budget of the Czech Geological Survey, under which continues to compile the yearbook. This enables the continuation of the unique research (and its publication) regarding the geological evolution of the area of the Czech Republic, economic situation of domestic mining companies, relation of mining to nature protection and regarding the expenses of rectifying negative impacts of mining in the Czech Republic.

The publication is published and distributed only in electronic form.

The publication continues to provide information for those interested in the research, exploration and mining of mineral deposits in the Czech Republic and in the environmental impact of mining in the Czech Republic. It of course continues to cover the most important minerals of the Czech Republic that are or have recently been of industrial importance, but also those minerals, whose reserves or (approved and unapproved) resources have not been mined in the Czech Republic in the past. The listed minerals also include minerals unmined in the present and past, without existing resources and reserves, which are items of Czech foreign trade that can be monitored via tariff items. The publication includes basic data on the status and changes in the mineral reserves of the Czech Republic taken from the Register of Mineral Deposit Reserves of the Czech Republic *(Bilance zásob výhradních ložisek nerostů České republiky)* (hereinafter “the Register”), which is published for a limited number of state administration agencies.

Additional information on domestic prices of minerals, imports and exports, major mining companies, and the location of mineral deposits is intended to assist in understanding the mineral potential of the Czech Republic and to stimulate investment in the minerals industry. This is also aided by the listed prognostic resources, both officially approved by the Commission for Projects and Final Reports of the Ministry of the Environment *(Komise pro projekty a závěrečné zprávy – KPZ)* in categories P_1, P_2, P_3 and unapproved by KPZ (mentioned only in expert reports).

The mineral reserves presented are geological reserves, also called *total reserves*, i.e. original reserves (in situ) within individual deposits, estimated according to the given classification and technical-economic conditions of their exploitability. The initial data come from mineral reserve estimates, which were approved or verified in the past by the Commission for Classification of Mineral Reserves and/or by the Commission for Exploration and Mining of Reserved Minerals of the former MHPR ČR and MH ČR, or by former commissions for management of mineral reserves of individual mining and processing industries. Uranium reserves and reserve estimates were approved by the Commission for Classification of Radioactive Mineral Reserves of the former Federal Ministry of Fuels and Energy. Currently, an approval of a reserve estimation lies within authority of the subject financing the estimation. If the subject is a private company, the company itself approves its reserve estimation. If the subject is the state, the KPZ approves the estimation. In accordance with section 14, article 3) of the Mining Act no. 44/1988 Coll. as amended also the private company submits its reserved mineral reserve estimation to the KPZ via the Ministry of the Environment of the Czech Republic, so that the KPZ may review if the estimation report contents comply with the provisions of the Mining Act.

There are reserved and non-reserved minerals and deposits as defined by the Mining Act no. 44/1988 Coll., as amended. Reserved minerals always form reserved deposits which are owned by the Czech Republic. Non-reserved deposits are owned by landowners. Non-reserved minerals (construction minerals) can form both reserved and non-reserved deposits. Until 1991, (important) deposits of non-reserved minerals of sufficient mineral quantity and quality were proclaimed „suitable for the needs and development of the national economy", hence reserved as defined by the Mining Act at that time. Since 1991, the newly recognised and explored deposits of non-reserved minerals always form non-reserved deposits.

In 1993–2001, the Ministry of the Environment along with the Ministry of Industry and Trade undertook a fundamental economic revaluation of the mineral wealth of the Czech Republic. In 2003–2006, the task has continued to a smaller extent. Therefore compared to past years, many considerable changes have occurred in the number of deposits and registered reserves of many minerals (especially metallic ores).

The *Mineral Commodity Summaries of the Czech Republic* includes selected minerals according to whether they are or were mined in the territory of the Czech Republic. Currently mined minerals also include approved prognostic resources, if existing. Currently unmined minerals are divided into those that were mined in the past and those that have never been mined. In both cases, it is distinguished whether their resources and reserves are known or not and, generally, also whether they are metallic ores or industrial minerals. Separate chapters are dedicated to each mineral, or mineral grouping common in its deposit. Each chapter is structured identically – consists of eight parts.

Part 1. – Characteristics and use – provides a basic description of the mineral raw material, its abundance in nature, important minerals and mineral deposit types, worldwide and European Union reserves, general use and allocation to the critical raw materials of the European Union.

Part 2. – Mineral resources of the Czech Republic – describes to the extent necessary major regions of occurrence, characteristics of deposits, ore types, mining and its economic aspects of the given mineral.

Part 3 – Registered deposits and other resources of the Czech Republic – is based on the inventory of mineral deposits of the Czech Republic and, for the majority of minerals, includes a list of deposits and their location. The names of exploited deposits are given in bold. As for energy minerals and some industrial minerals, only regions and basins rather than single deposits are given. As for dimension stone and construction minerals, which are scattered in hundreds of deposits over the whole territory of the Czech Republic, their groupings are located in the subdivisions of reserved, non-reserved, exploited and unexploited deposits.

Part 4 – Basic statistical data of the Czech Republic as of December 31 – are extracted especially from the Register. There are 3 groups of minerals (ores, energy minerals, and reserved industrial and construction minerals) registered in the Czech Republic. Mine production of non-reserved deposits has been monitored since 1999. Approved prognostic resources are stated, too, if proved they exist.

*NOTE: The Register presents the reserves data in the categories on exploration (prospected, explored) and economic use (economic, potentially economic), as stipulated by relevant statutes starting with the Mining Act. Reserves include potentially economic reserves, i.e. reserves which are currently not recoverable and which are, therefore, potentially economic resources. Consequently, total mineral reserves are in reality total mineral resources. The term reserves as used, by contrast, in standard international classifications represents only the parts of explored resources which are available for immediate extraction. All other registered parts are resources, not reserves, of a given mineral. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter of this yearbook "**Mineral reserve and resource classification in the Czech Republic and its evolutional comparison with international classifications**".*

Part 5 – Foreign trade – provides information on import and export, and on average import and export prices of important tariff items of the given raw material (and cites international numeric codes of the tariff items). The foreign trade data are the latest (continuously reviewed) data of the Czech Statistical Office (ČSÚ) – without analyses of their reliability.

Part 6 – Prices of domestic market – provides indicative prices on domestic production, import and export prices. Domestic prices do not include VAT.

Part 7 – Mining companies in the Czech Republic as of December 31, 2021 – provides a list of companies mining the given mineral in the territory of the Czech Republic. The companies are listed according to the production level. Their addresses are available at the Czech Geological Survey.

Part 8 – World production and world market prices – provides data on mining and production of commercial products for the last 5 years, and lists significant world producers, i.e. the top ten countries in world production. Evolution of world prices is mentioned as current quoted or indicative prices in the last five years.

Numerous domestic and foreign data, used in compiling the present yearbook, came from journals, expert literature and the latest editions of various international statistical yearbooks.

EXPLANATORY NOTES

List of abbreviations, symbols and technical units

AOPK ČR Nature Conservation Agency of the Czech Republic (Agentura ochrany přírody a krajiny České republiky)

API American Petroleum Institute

API degrees Degrees of crude oil specific gravity defined by the API (°API)
API gravity formulas:

$$°API = \frac{141.5}{SG\ at\ 60°F} - 131.5$$

$$SG\ at\ 60°F = \frac{141.5}{°API + 131.5}$$

SG = specific gravity (t/m^3)
60° F = 15.6° C

a.s. initials after a Czech company name indicate that it is a joint stock company (akciová společnost)

bbl barrel of crude petroleum, 158.99 dm^3; 1 tonne of crude petroleum is approximately 7 bbl (6.76-7.75 bbl for crude petroleum extracted in the Czech Republic)

bn billion, 10^9

BP British Petroleum, British multinational oil and petrochemical company

BP SRWE British Petroleum Statistical Review of World Energy, energy yearbook including energy minerals

CFR Cost and Freight (named port of destination)

CHKO protected landscape area (Chráněná krajinná oblast)

CHLÚ protected deposit area (Chráněné ložiskové území)

CHOPAV Protected area of natural accomodation of water (chráněná oblast přirozené akumulace vod) – see PANAW

CIF Cost, Insurance and Freight (named port of destination)

CIS Commonwealth of Independent States, in Russian: Содружество Независимых Государств

CMMI Council of Mining and Metallurgical Institutions

Coll. Collection of laws (Sbírka zákonů České republiky) of the Czech Republic

CSO Czech Statistical Office

CZK Czech crown (česká koruna)

CZ NACE Czech adoption of the General Industrial Classification of Economic Activities within the European Communities (Nomenclature générale des Activités économiques dans les Communautés Européennes)

ČBÚ Czech Mining Authority (Český báňský úřad)

ČGÚ Czech Geological Office (Český geologický úřad)
ČNB Czech National Bank (Česká národní banka)
ČNR Czech National Council (Česká národní rada) – former parliament of the Czech (Socialist) Republic
ČR Czech Republic (Česká republika)
ČSSR Czechoslovak Socialist Republic (Československá socialistická republika)
ČSÚ Czech Statistical Office (Český statistický úřad)
DERA Deutsche Rohstoffagentur (German Mineral Resources Agency) is a part of Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources)
DP mining lease (dobývací prostor)
EIA 1) Environmental Impact Assessment
2) Energy Information Administration, section of the Department of Energy of the USA providing energy statistics, data, analysis
EU European Union
EURATOM Euratom Supply Agency (ESA), European agency for common supply policy on the principle of regular and equitable supply of nuclear fuels for European Community users
EUROSTAT Statistical Office of the European Communities, organisational branch of the European Commission
FDI foreign direct investment
FMPE Federal Ministry of Fuels and Power (Federální ministersvo paliv a energetiky)
FNM National property Fund (Fond národního majetku)
FOB Free on Board (port) – seller pays for transportation of the goods to the port of shipment, plus loading costs
GDP Gross domestic product
GVA Gross value added (GVA) is a widely used indicator of the total economic performance of each branch. It is an indicator corresponding to the GDP in the whole national economy. It is calculated by subtraction of the intermediate consumption (consumption of the raw materials, energy, materials) from the total value of the production (in terms of accounting, this is the difference between the sales and other services of companies and their consumption of materials, energy and services, this is therefore the sum of their book values added)
IEA International Energy Agency
IM Industrial Minerals (journal)
IMF International Monetary Fund
JORC Joint Ore Reserves Committee - comprises representatives of each of the three parent bodies: The Minerals Council of Australia (MCA), The Australasian Institute of Mining and Metallurgy (The AusIMM), and the Australian Institute of Geoscientists (AIG); as well as representatives of the Australian Securities Exchange (ASX), the Financial Services Institute of Australasia (FinSIA) and the accounting profession, and an observer from Association of Mining and Exploration Companies (AMEC). The JORC Committee is responsible for the development and ongoing update of the JORC Code. The JORC Code provides a mandatory system for the classification of minerals

	exploration Results, mineral resources and ore reserves according to the levels of confidence in geological knowledge and technical and economic considerations in Public Reports.
KKZ	Commission for Classification of Mineral Reserves (Komise pro klasifikaci zásob)
k.s.	initials after a Czech company name indicate that it is a limited partnership company (komanditní společnost)
kt	kilotonne, 1,000 t
Ma	Million of years
MB	Metal Bulletin (journal)
MCS	Mineral Commodity Summaries, mineral yearbook of the US Geological Survey
MF	Ministry of Finance
MH ČR	Ministry of Economy of the Czech Republic (Ministerstvo hospodářství České republiky)
MHPR	Ministry of Economic Policy and Development (Ministerstvo pro hospodářskou politiku a rozvoj)
mill	million, 10^6
MIT	Ministry of Industry and Trade
MoE	Ministry of the Environment
MoLSA	Ministry of Labour and Social Affairs (Ministerstvo práce a sociálních věcí)
MŽP ČR	Ministry of the Environment of the Czech Republic (Ministerstvo životního prostředí České republiky)
N	not available or not reliable data
NP	natural park (Národní park)
NPF	National Privatization Fund
OBÚ	Regional Mining Authority (obvodní báňský úřad)
OPEC	Organization of Petroleum Exporting Countries
o.p.s.	initials after a Czech organization name indicate that it is a not profit organization (obecně prospěšná společnost)
PANAW	Protected area of natural accomodation of water (chráněná oblast přirozené akumulace vod) – see CHOPAV
pcs	pieces
PKÚ	Palivový kombinát Ústí, s.p.
POPD	plan of mine development work of reserved mineral deposits (plán otvírky, přípravy a dobývání výhradních ložisek)
ppm	parts per million = 0.0001 = g/t
ROPO	Recognised Overseas Professional Organizations
Sb.	Collection of Laws (abbreviated as Coll.) of the Czech Republic
SD	Severočeské doly, a.s.
s.p.	initials after a Czech company name indicate that it is a state public enterprise (státní podnik)
spol. s r.o.	initials after a Czech company name indicate that it is a limited liability company (společnost s ručením omezeným), ditto initials s. r. o.
s. r.o.	initials after a Czech company name indicate that it is a limited liability company (společnost s ručením omezeným), ditto initials spol. s r.o.

SU	Sokolovská uhelná, právní nástupce, a.s.
t	metric tonne, 1,000 kg, 1,000,000 g
tce	tonne of coal equivalent, the energy unit representing energy 7 million kcal (29,3067 GJ) generated by burning one metric ton of coal; Czech steam coal 1 tce = 1.1–1.6 t, coke coal 1.0–1.3 t
ths	thousand, 10^3
UNFC	United Nations Framework Classification
USGS	United States Geological Survey – Geological survey of the USA
v.o.s.	initials after a Czech company name indicate that it is an unlimited company (general partnership) (veřejná obchodní společnost)
VAT	Value Added Tax
WBD	Welt Bergbau Daten (World Mining Data), mineral yearbook of Austrian Federal Ministry of Agriculture, Regions and Tourism
WNA	World Nuclear Association
ZCHÚ	specially protected area (zvláště chráněné území)

Exchange and inflation rates of currencies in which minerals are priced

Annual inflation rates (%) in the USA (US), the United Kingdom (UK), the Euro Area (EUR) and the Czech Republic (CZ)

	US	UK	EUR	CZ
1991	4.2	7.4	–	56.6
1992	3.0	4.3	–	11.1
1993	3.0	2.5	–	20.8
1994	2.6	2.1	–	10.0
1995	2.8	2.6	–	9.2
1996	2.9	2.4	–	8.8
1997	2.3	1.8	–	8.4
1998	1.5	1.6	–	10.6
1999	2.2	1.3	1.1	2.3
2000	3.4	0.9	2.1	3.8
2001	2.8	1.2	2.4	4.7
2002	1.6	1.3	2.3	1.8
2003	2.3	1.4	2.1	0.1
2004	2.7	1.3	2.1	2.8
2005	3.4	2.0	2.2	1.8
2006	3.2	2.3	2.2	2.5
2007	2.9	2.3	2.2	2.9
2008	3.8	3.6	3.3	6.3
2009	-0.3	2.2	0.3	1.0
2010	1.6	3.3	1.6	1.5
2011	3.1	4.5	2.7	1.9
2012	2.1	2.8	2.5	3.3
2013	1.5	2.6	1.3	1.4
2014	1.6	1.5	0.4	0.4
2015	0.1	0.0	0.2	0.3
2016	1.3	0.7	0.2	0.7
2017	2.1	2.7	1.5	2.5
2018	2.4	2.5	1.8	2.2
2019	1.8	1.8	1.2	2.9
2020	1.3	0.9	0.3	3.2
2021	4,7	2,5	2,6	3,8*

*Notes: * Czech Statistic Office*

- *source – IMF. World Economic Outlook. October 2022*
- *inflation rates based on average annual changes of consumer price indices*

Average yearly exchange rates of CZK against EUR, USD and GBP

	EUR	USD	GBP
1991	–	29.5	52.0
1992	–	28.3	49.9
1993	–	29.2	43.8
1994	–	28.8	44.0
1995	–	26.5	41.9
1996	–	27.1	42.3
1997	–	31.7	51.9
1998	–	32.3	53.5
1999	36.9	34.6	56.0
2000	35.6	38.6	58.4
2001	34.1	38.0	54.8
2002	30.8	32.7	49.0
2003	31.8	28.2	46.0
2004	31.9	25.7	47.1
2005	29.8	23.9	43.6
2006	28.3	22.6	41.6
2007	27.8	20.3	40.6
2008	24.9	17.0	31.4
2009	26.4	19.1	29.7
2010	25.3	19.1	29.5
2011	24.6	17.7	28.3
2012	25.1	19.6	31.0
2013	26.0	19.6	30.6
2014	27.5	20.7	34.2
2015	27.3	24.6	37.6
2016	27.0	24.4	33.1
2017	26.3	23.4	30.1
2018	25.6	21.7	29.0
2019	25.7	22.9	29.3
2020	26.4	23.2	29.7
2021	25.7	21.7	29.8

Source: Czech National Bank

Mineral reserve and resource classification in the Czech Republic and its evolutional comparison with international classifications

Czech classification

After 1948 the reserve classification of the USSR was progressively adopted in Czechoslovakia, of which the Czech Republic formed part. A Commission for Classification of Mineral Reserves (*Komise pro klasifikaci zásob – KKZ*) was established in 1952, as a state agency to review the categorisation and estimation of reserves of all types of minerals, except radioactive ores.

Initially geological reserves (all reserves in their original state in the deposit without subtracting losses from mining, beneficiation and processing) were classified into subdivisions of groups and categories (slightly simplified).

Groups of geological reserves according to industrial utilisation

Nebilanční potentially economic – currently unminable due to a low grade, small deposit thickness, particularly complicated mining conditions, or due to the unfamiliarity with economic processing methods for the given mineral type, yet which may be considered as exploitable in the future.

Bilanční economic – minable, suitable for industrial utilisation and for the technical mining conditions for extraction.

Categories of geological reserves according to the degree of deposit exploration:

A – explored in detail and delimited by mining works or boreholes, or by a combination of these. Geological setting, distribution of quality mineral types in the deposit and the technological properties of the mineral are known to such a degree that allow for the development of a method for beneficiation and processing of the mineral. Natural and industrial types of minerals are given. Reserves A include those parts of the deposit, where the geological setting, hydrogeological conditions and mining conditions are known to such a degree that a deposit development method can be developed.

B – explored and delimited by mining works or boreholes, or by a combination of these in a sparser network than in category A. It further includes reserves of deposits adjoining blocks of category A, verified by exploration works. The manner of geological setting, natural and industrial types of minerals are determined without knowing their detailed distribution in the deposit. The quality and technological characteristics of the minerals are given within a range allowing for a basic choice of a processing method. Hydrogeological conditions and general principles of deposit development are sufficiently clarified.

$\mathbf{C_1}$ – determined by a sparse network of boreholes or mining works, or by a combination of these, as well as reserves which adjoin the reserves of categories A and B, if they are justified from a geological perspective. They also include the reserves of relatively complex deposits with a very irregular distribution of the mineral, even though these deposits were explored in detail. Included here are the deposit reserves partially mined-out with low recovery methods. The setting conditions, quality, industrial types and processing technology of the mineral are defined based on analyses or laboratory tests of samples, or based on analogy with explored deposits of a similar type. The hydrogeological conditions and the principles of deposit development are defined quite in general.

C_1 – determined by a sparse network of boreholes or mining works, or by a combination of these, as well as reserves which adjoin the reserves of categories A and B, if they are justified from a geological perspective. They also include the reserves of relatively complex deposits with a very irregular distribution of the mineral, even though these deposits were explored in detail. Included here are the deposit reserves partially mined-out with low recovery methods. The setting conditions, quality, industrial types and processing technology of the mineral are defined based on analyses or laboratory tests of samples, or based on analogy with explored deposits of a similar type. The hydrogeological conditions and the principles of deposit development are defined quite in general.

C_2 – are assumed based on geological and geophysical data, confirmed by sampling of the mineral deposit from outcrops, isolated boreholes or mining works. Also, reserves adjoining the reserves of A, B, C_1categories, where geological conditions for this exist.

It is further defined that project development and investment amounts for the construction of mining facilities are permitted on the basis of the economic mineral reserves in categories A + B + C_1, which are therefore reserves eligible for industrial utilisation. That is why, in practice, the economic reserves of categories A, B, C_1, or their total A + B + C_1 were designated by the term industrial reserves.

Further improvement of the classification introduced Order of the ČSSR Government no.80 in 1988 [7].

In 1963, KKZ established the prognostic reserves *(prognózní zásoby)* category in an amendment of its Principles for the Classification of Solid Minerals (hereinafter Principles) *(Zásad pro klasifikaci zásob pevných nerostných surovin)*. They were defined as unexplored mineral reserves, assumed on the basis of the formation patterns and the distribution of mineral deposits, and investigations, dealing with the geological structure and the history of geological evolution of the evaluated locality. The parameters for the evaluation of prognostic reserves (strike, length, thickness, average grade and the like) are determined according to geological assumptions or they are derived. According to the Principles, prognostic reserves are not listed in the national Register of Reserves *(bilance zásob)*. They serve only as a basis for future planning of geological exploration.

In 1968, KKZ innovated the definition of prognostic reserves. In the amended Principles for reserve classification, it established the division of reserves into proved (by exploration or mining) and assumed, or prognostic. Prognostic geological reserves are unverified reserves, however they are assumed based on geological, geophysical and other scientific knowledge and material. They are predominantly the reserves of larger localities and formations, and, in isolated cases, the reserves of unexplored parts of large structures or deposits.

Due to the establishment of the prognostic reserve category, geological reserves *(geologické zásoby)* can, with regard to contents, be translated into English as total resources. However up to 1989, the term resources did not appear in Czech or Czechoslovak classifications. But up to now, reserves also represent mineral accumulations, which meet the reserves criteria due to being explored, but which do not meet them due to technical and economic reasons (potentially economic reserves *nebilanční zásoby*). They are therefore mineral resources.

In 1981, the Czech Geological Office issued Directive No. 3 [3], where the present prognostic reserves *(prognózní zásoby)* were divided into categories D_1, D_2, D_3. They are defined as follows:

D_1 – relate to verified mineral deposit reserves, with which they form one whole deposit. Determined in delimited areas and quantifiable based on positive detection of an existing mineral and its basic quality characteristics.

D_2 – territorially independent. They are determined in a delimited area based on positive detection of an existing mineral and its basic quality characteristic. Analogies are also used for their determination.

D_3 – determined on the basis of regional investigation. So far, mineral existence has not been proven in such a way, in order to be able to delimit the area of their occurrence and to quantify the prognosis.

In October 1989, the Czech Geological Office issued Decree No. 121/1989 Coll., which redefined the prognostic reserve categories, changed their designation, and for the first time in the Czech Republic established the term resources. The term prognostic resources has been used instead of the term prognostic reserves ever since. The categories P_1, P_2, P_3 were as follows:

P_1 – assumed due to the continuation of an already investigated deposit beyond the reserve outline of category C_2 or due to the discovery of new deposit parts (bodies). The basis for this category are the results of geological mapping, geophysical, geochemical and other work in the area of possibly occurring prognostic resources: geological extrapolation of data results from the investigation, or the verification of part of the deposit. In justified cases this category also includes areas with isolated technical works which do not fulfill the requirements in order to be included in the reserves category C_2. The quantity and quality of the prognostic resources of this category is estimated according to the given deposit type and its part with detected reserves.

P_2 – assumed in basins districts and geological regions, where deposits of the same formation and generation type were detected. It is based on a positive evaluation of deposit indications and anomalies observed during geological mapping and geophysical, geochemical and other work, whose prospect is, if necessary, confirmed by a borehole or surface excavation work. The prognostic resource estimate of assumed deposits and the concept of the shape and dimensions of the bodies, their composition and quality, are derived by analogy with known deposits of the same type.

P_3 – assumed solely on the basis of conclusions concerning the formation possibilities of the deposit types under consideration with regard to favourable stratigraphic, lithological, tectonic and paleogeographic conditions detected while evaluating the locality during geological mapping, and during analysis of geophysical and geochemical data. The quantity and quality of prognostic resources is estimated according to assumed parameters of the deposit development by analogy with more closely explored localities, where deposits of the same genetical type were detected or verified. The prognostic resources of minerals in category P_3 can only be displayed by a surface projection.

The amendment of Mining Act no. 541/1991 Coll. divided the classification of reserves (reserved deposits) according to exploration into the categories of prospected reserves (*vyhledané zásoby)* and explored reserves *(prozkoumané zásoby)*, and, according to exploitability conditions, into economic reserves *(zásoby bilanční)* and potentially economic reserves *(zásoby nebilanční)* .

Economic – reserves suitable for existing technical and economic conditions in exploiting a reserved deposit.

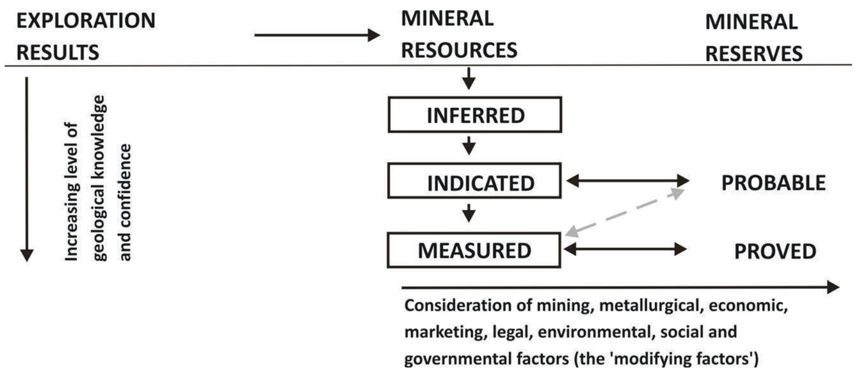
Potentially economic reserves – currently unexploitable due to being unsuitable for existing technical and economic conditions of exploitation, yet assumed to be exploitable in the future in consideration of expected technical and economic development.

Neither this amendment nor any other regulation defined the content of the terms **prospected** and **explored** reserves. In practice, these categories are identified with the categories of reserve exploration, as they were in effect before the amendement of Mining Act no. 541/1991 Coll., in the following manner: explored reserves = sum of reserve categories A + B + C_1 (also called industrial), prospected reserves = reserves of category C_2.

International classifications

International systems of classifying reserves and resources developed rapidly in the last quarter of the twentieth century. In 2001, the Pan European Reserves and Resources Reporting Committee (PERC) published Code for Reporting of Mineral Exploration Results, Mineral Resources and Mineral Reserves [1]. This corresponds to the reporting standards of the Australian, Canadian, South African and other organisations grouped in the Combined Reserves International Reporting Standards Committee (now called Committee for Mineral Reserves International Reporting Standards) – CRIRSCO which is a subcommittee of CMMI (Council of Mining and Metallurgical Industries). It is summarized as follows:

Relations between mineral reserves and resources, their definitions
Chart of the relations [1]

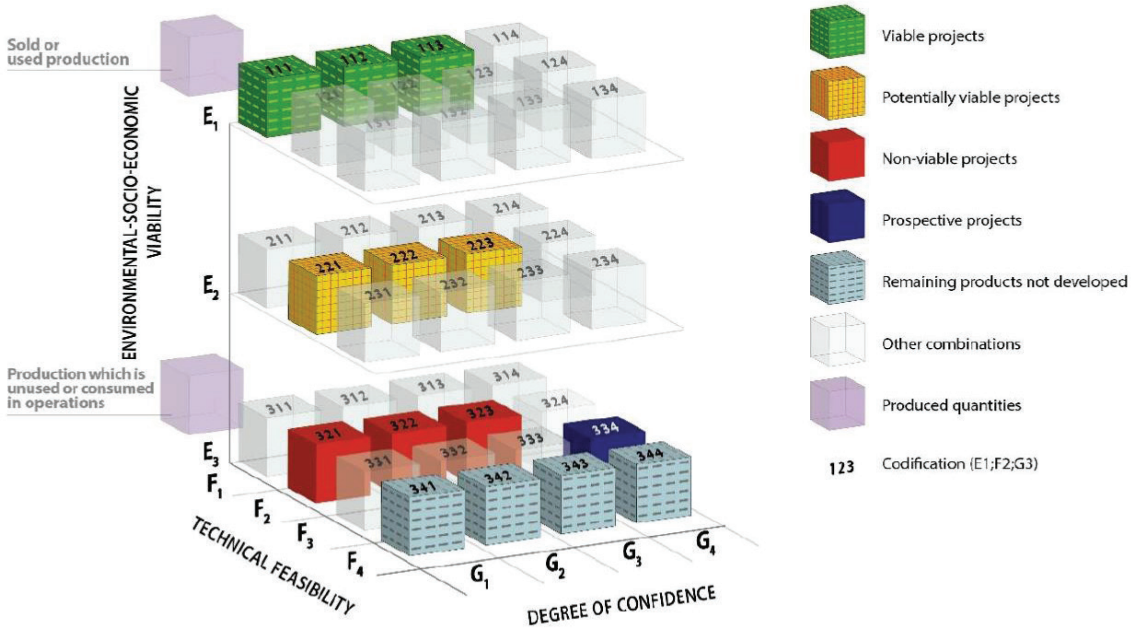


The given definitions are in accordance with the definitions of the UNFC (United Nations Framework Classification) of the UN, published by UN-ECE in 1997 [4] and updated in 2009 [10] and 2019 [11]. This classification is a resource project-based and principles-based classification system for for defining the environmental-socio-economic viability and technical feasibility of projects to develop resources. UNFC provides a consistent framework to describe the level of confidence of the future quantities produced by the project.

Sources, such as solar, wind, geothermal, hydro-marine, bioenergy, injection for storage, hydrocarbons, minerals, nuclear fuels and water, are the feedstock to resource projects from which products can be developed. The sources may be in their natural or secondary (anthropogenic sources, tailings, etc.) state.

UNFC has been designed to meet, to the extent possible, the needs of applications pertaining to the policy formulation based on resource studies, resources management functions, corporate business processes, and financial capital allocation [11]. However, currently it is not legally registered standard for financial reporting such as JORC, PERC or Canadian NI44-101. It is being introduced by EU as a tool for harmonising all types of resource data within EU and consequently enable coherent policy formulation [12].

UNFC is a principles-based system in which the products of a resource project are classified on the basis of the three fundamental criteria of environmental-socio-economic viability (E), technical feasibility (F), and degree of confidence in the estimate (G), using a numerical coding system. E, F and G are axis of a 3D chart, in which the projects are grouped into specific categories. There are 4 levels on the F and G axis, while E axis carries 3 levels. Thus a total of 40 categories can be established mechanically, out of which 14 are actually within reason



UNFC categories and examples of Classes [11]

and are grouped into Classes. The categories are marked with a three-digit code, and more detailed subcategories are also defined for more precise specification. Combinations of these criteria create a three-dimensional system as depicted on the following chart:

UNFC is aligned with other classification systems via Bridging Documents. A Bridging Document explains the relationship between UNFC and another classification system, including instructions on how to classify estimates generated by application of that system using the UNFC Numerical Codes and vice versa.

Corporate estimates reported or published in accordance with CRIRSCO Template can be coded into UNFC categories by making simplifying assumptions following the mapping presented in the following table:

CRIRSCO Template		UNFC-2009 "minimum" Categories			UNFC-2009 Class
Mineral Reserve	Proved	E1	F1	G1	Commercial Projects
	Probable			G2	
Mineral Resource	Measured	E2	F2	G1	Potentially Commercial Projects
	Indicated			G2	
	Inferred			G3	
Exploration Results		E3	F3	G4	Exploration Projects

Simplified mapping of CRIRSCO template to UNFC-2009 Classes and Categories [11]

(Notice: In the course of discovery and verification of mineral deposits and their estimations of mineral resources and reserves two fundamental stages connect at each other: prospecting and exploration.

Prospecting is a set of geological activities aiming at discovery of a mineral accumulation (mineral accumulations) which could be a mineral deposit (mineral deposits) and to express in numbers its (their) mineral resources.

Exploration is to decide if a mineral accumulation (prospective mineral deposit) is a mineral deposit or not and if it is, to estimate its mineral reserves.)

An important aspect of the European and similar reporting codes is the concept of the "competent person". He/she is responsible for the calculation of reserves and its categories, is a member of an acknowledged professional society (which sees to the expertise and ethics of its members via sanctions), and has expert and moral qualities. His estimates are accepted as reliable by banks and securities exchanges. Competent persons are members of Recognized Overseas Professional Organizations (ROPO). A list of organisations is compiled by the Australasian Joint Ore Reserves Committee (JORC).

Although some national and international classifications are relatively complicated, the mining industry frequently still makes do with only the categories of proved and probable reserves. If it is seeking funds from banks or share issues (initial public offering) on securities exchanges, it must respect the regulations for reporting its mineral reserves. The securities exchanges have reporting requirements which are particularly strict or even provided by law. In general they require adherence to the reporting codes of the international organizations such as those that cooperate in framing the European Code [1].

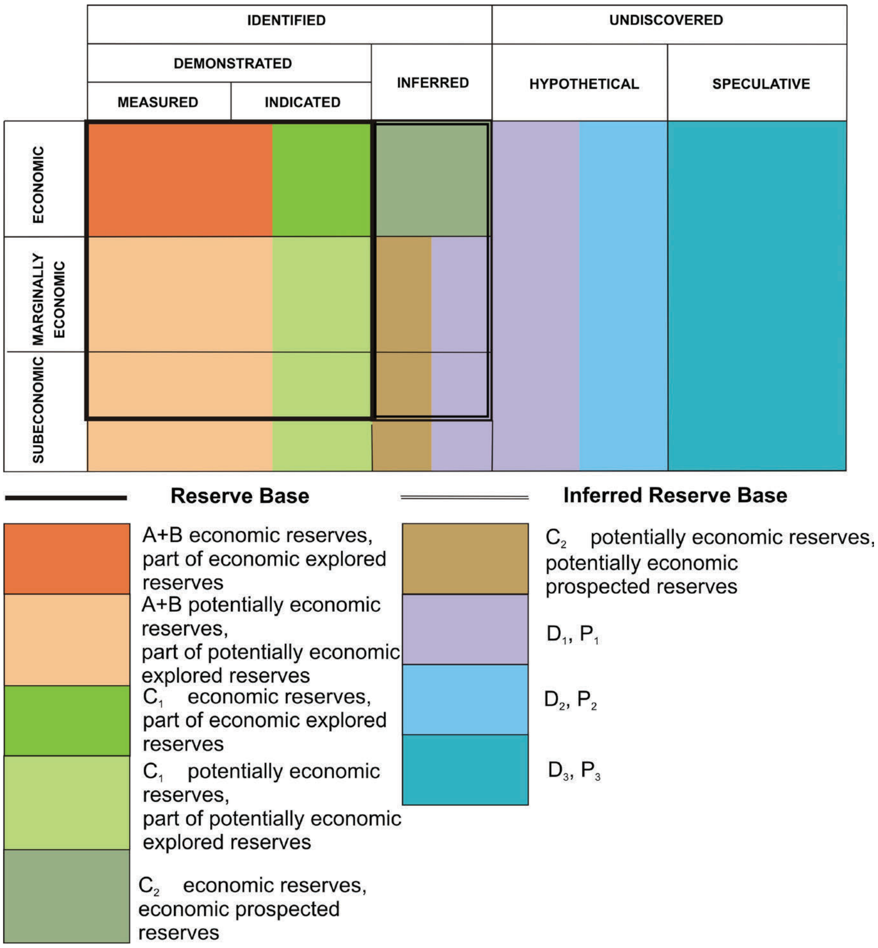
Comparison of Czech and international systems of classification

The following scheme and table compare the reserve and resource classifications of the Czech Republic with the international classifications discussed above.

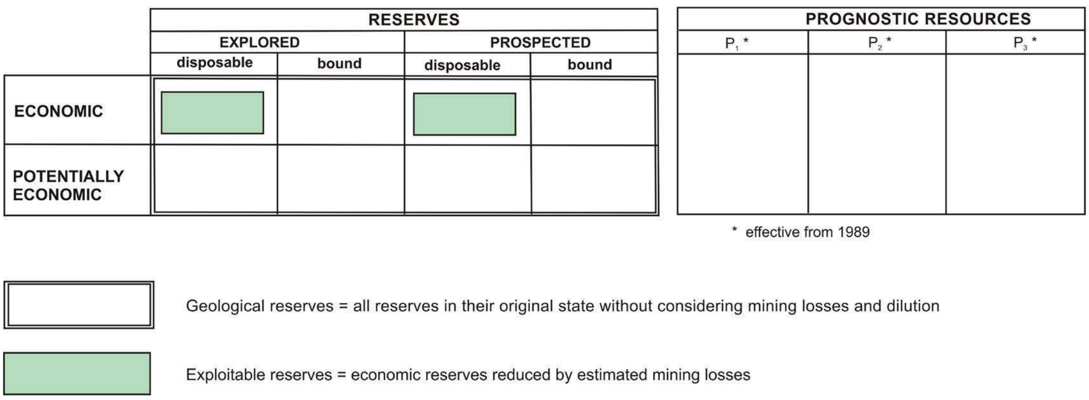
Is to be noted that reserves in the Czech classification still include potentially economic reserves, i.e. reserves which are currently not recoverable and which are, therefore, potentially economic resources. The term reserves as used, by contrast, in standard international classifications represents only the parts of explored resources which are available for immediate or developed extraction. All other registered parts are resources, not reserves, of a given mineral. Is to be also mentioned that the standard international classifications indicate reserves considering mining recovery and dilution. On the other hand the Czech reserves are mentioned in situ, without influence of recovery and dilution. Therefore Czech economic recoverable (exploitable) reserves are the nearest to the international standards. However, even in this case there is no full accord as this reserves consider recovery of reserves but not their dilution.

An attempt to compare the Czech national system of classification with UNFC was done in the past based on the UNFC 2009 update [10]. This work revealed serious discrepancies since many of the UNFC categories are overlapping several national categories. A Bridging Document to the UNFC 2019 update [11] has still to be elaborated.

Comparison of the mineral resource classification valid in the USA from 1980 [5] with the reserve and resource classifications valid in the territory of the Czech Republic from 1956



HISTORY OF RESERVE AND RESOURCE CLASSIFICATION ON THE TERRITORY OF THE CZECH REPUBLIC



reserves of categories A + B + C (before 1991) = explored reserves (since 1991)
reserves of category C_2 (before 1991) = prospected reserves (since 1991)
disposable reserves = reserves mining of which is not made impossible by protection of surface objects and mining workings
bound reserves = reserves in protection pillars of surface objects and mining workings
exploitable reserves = economic geological reserves reduced by amount of prospective mining losses connecting with selected mining technology or with natural conditions
categories A, B, C_1 = so-called industrial categories of reserves (before 1991)
reserve of categories A + B + C_1 = so-called industrial reserves (before 1991), also - in the limited interpretation - economic explored disposable reserves

Comparison of UNFC 2009 [10] with the reserve and resource classifications of the Council of Mining and Metallurgical Industries (CMMI) [4] and of the Czech Republic

Code of the UNFC category	Proposed designation of the UNFC category	CMMI category	Czech categories up to 1981	Czech categories in 1981–1989	Czech categories in 1989–1991	Czech categories after 1991
111	Proved Mineral Reserve	Proved Mineral Reserve	economic reserves – part of exploitable part* A + B	economic reserves – part of exploitable part* A + B	economic reserves – part of exploitable part* A + B	part of exploitable part* of explored economic reserves
121 + 122	Probable Mineral Reserve	Probable Mineral Reserve	economic reserves – part of exploitable part* of A + B + C_1	economic reserves – part of exploitable part* of A + B + C_1	economic reserves – part of exploitable part* of A + B + C_1	part of exploitable part* of explored economic reserves
123		Inferred Mineral Resource	economic reserves – C_2	economic reserves – C_2	economic reserves – C_2	prospected economic reserves
211	Feasibility Mineral Resource	Measured Mineral Resource	potentially economic reserves – A + B	potentially economic reserves – A + B	potentially economic reserves – A + B	part of explored potentially economic reserves
221 + 222	Prefeasibility Mineral Resource	Indicated Mineral Resource	potentially economic reserves – C_1	potentially economic reserves – C_1	potentially economic reserves – C_1	part of explored potentially economic reserves
223		Inferred Mineral Resource	potentially economic reserves – C_2	potentially economic reserves – C_2	potentially economic reserves – C_2	prospected potentially economic reserves
331	Measured Mineral Resource	Measured Mineral Resource	potentially economic reserves – A + B	potentially economic reserves – A + B	potentially economic reserves – A + B	part of explored potentially economic reserves
332	Indicated Mineral Resource	Indicated Mineral Resource	potentially economic reserves – C_1	potentially economic reserves – C_1	potentially economic reserves – C_1	part of explored potentially economic reserves
333	Inferred Mineral Resource	Inferred Mineral Resource	potentially economic reserves – C2 + part of prognostic reserves	potentially economic reserves + part of D_1	potentially economic reserves + part of P_1	prospected potentially economic reserves + part of P_1
334	Reconnaissance Mineral Resource	not available	part of prognostic reserves	D_2 + D_3+ part of D_1	P_2 + P_3+ part of P_1	P_2 + P_3+ part of P_1

** geological reserves reduced by amount of prospective mining losses*

Comparison of classifications of resources and reserves valid in the Czech Republic in the years 1989–1991 and after 1991 with classification standards PERC and JORC taking into account [8] and with classification standards ot Canadian Institute of Mining, Metallurgy and Petroleum (CIM) used by guideline NI 43-101 for the publication of the economics of mineral projects in Canada (on the Toronto Stock Exchange – TSX) [9]

Standards PERC a JORC	Canadian CIM standards used by NI 43-101	Czech categories in 1989–1991	Czech categories after 1991
Proved reserves	Proven reserves	A bilanční vytěžitelné zásoby (economic exploitable reserves)	Bilanční prozkoumané vytěžitelné zásoby (economic explored exploitable reserves)
		B bilanční vytěžitelné zásoby (economic exploitable reserves)	
		C_1 bilanční vytěžitelné zásoby (economic exploitable reserves)*	
Probable reserves	Probable reserves	C_1 bilanční vytěžitelné zásoby (economic exploitable reserves)	Bilanční vyhledané vytěžitelné zásoby (economic prospected exploitable reserves)
		C_2 bilanční vytěžitelné zásoby (economic exploitable reserves)	
Measured resources	Measured resources	A nebilanční zásoby (potentially economic reserves)	Nebilanční prozkoumané zásoby (potentially economic explored reserves)
		B nebilanční zásoby (potentially economic reserves)	
		C_1 nebilanční zásoby (potentially economic reserves)*	
Indicated resources	Indicated resources	C_1 nebilanční zásoby (potentially economic reserves)	Nebilanční vyhledané zásoby (potentially economic prospected reserves)
		C_2 nebilanční zásoby (potentially economic reserves)	
Inferred resources	Inferred resources	P1 prognózní zdroje (prognostic resources)	P_1 prognózní zdroje (prognostic resources)

** in the case of deposits with a complex geological structure*

Conclusions

If they are to be of practical use national and international classifications have to respect the information base given by the reserve estimations of mining enterprises. It may be unsuitable to overly expand the classification requirements or expectations beyond the realistic means of this base. Combining a classification with a study (project), which classifies given resources or reserves, or with a prospecting and exploration phase, in which mineral resources and reserves were estimated, causes problems. For economic (acquiring financial means, taxes, market position) or political reasons, a prospector or a mining company developer may be led, for example, to move their exploration phase higher or lower in comparison with its actual position. In socialist (communist) Czechoslovakia with its completely nationalised industry, commerce and services, results of geological prospecting and exploration were judged not according to the mineral reserves prospected or verified by exploration, but according to the fulfillment of exploration work plans, whether planned investments in exploration were completely spent on "drilling and digging", or not. The wage of the employees of exploration and mining organisations depended on the fullfilment of plans. That is why at all levels**,** there was also an interest, that prospecting and exploration constantly continue. Consequently, prospecting strictly speaking and general exploration were the most frequent type of prospecting, and verified reserves were possibly never categorised under A. They were commonly only inserted into categories C_1 and C_2. That enabled their permanent verification. On the other hand, many mining organisations mined the reserves of category C_2 which however could have been ranked factually higher; they were over-explored.

References

[1] Code for reporting of mineral exploration results, mineral resources and mineral reserves (The Reporting Code). – http://geolsoc.org.uk/webdav/site/GSL/shared/pdfs/Fellowship/UK_Euro%20Reporting%20Code.pdf

[2]* Schejbal, C. (2003): Problematika výpočtu a klasifikace zásob a zdrojů pevných nerostných surovin. – Sborník vědeckých prací Vysoké školy báňské – Technické univerzity Ostrava, ročník XLIX, řada hornicko-geologická, monografie 9, s. 139–161 (Transactions of the VŠB – Technical University Ostrava, vol. XLIX, Mining and Geological Series, Monograph 9, pp. 139–161).

[3]** Směrnice č. 3/1981 Českého geologického úřadu pro hodnocení a evidenci geologických prognóz a prognózních zásob nerostných surovin. – Geologický průzkum, 23, 10:Zpravodaj ČGÚ, 5:1–2.

[4] United Nations international framework classification for reserves/resources – solid fuels and mineral commodities. – United Nations Economic and Social Council, Economic Commission for Europe, Committee on Sustainable Energy, 1997. Geneva.

[5] U. S. Bureau of Mines and U. S. Geological Survey. Principles of a resource/reserve classification for minerals. – U. S. Geological Survey Circular 831, 1980.

[6]*** Lhotský, P. – Morávek, P. (2002): Ložiskový průzkum a hospodaření se zásobami výhradních ložisek (návrh k analýze třetí části horního zákona). – Uhlí, rudy, geologický průzkum, 5: 8–15.

[7]**** Nařízení vlády Československé socialistické republiky č.80/1988 Sb., o stanovení kondic, klasifikaci zásob výhradních ložisek a posuzování, schvalování a státní expertize jejich výpočtů.

[8]***** Pechar T. et al.(2016): Metodika umožňující srovnání údajů zastaralé metodiky hodnocení ložisek s nově navrženými kritérii hodnocení dle PERC a JORC.-Certifikovaná metodika č.2, projekt č. TB030MP013, TAČR Program Beta, MPO. Praha.

[9] CIM definition standards – For mineral resources and mineral reserves. Prepared by the CIM Standing Committee on Reserve Definitions. Adopted by CIM Council on May 10, 2014 (https://www.crirsco.com/docs/cim_definition_standards_20142.pdf)

[10] United Nations Framework Classification for Resources for Fossil Energy and Mineral Reserves and Resources 2009 incorporating Specifications for its Application. – ECE Energy Series No. 42, United Nations New York and Geneva, 2013. (https://unece.org/sustainable-energy/publications/united-nations-framework-classification-ece-energy-series-no-42)

[11] United Nations Framework Classification for Resources, Update 2019. – ECE Energy Series No. 61, United Nations Geneva 2020. (https://unece.org/sustainable-energy/publications/united-nations-framework-classification-resources-update-2019-ece)

[12] UNFC Guidance for Europe. Guidance for the Application of the United Nations Framework Classification for Resources (UNFC) for Mineral and Anthropogenic Resources in Europe.United Nations, Geneva, 2022. (https://unece.org/draft-guidance-application-unfc-mineral-and-anthropogenic-resources-europe)

Translations of Czech article (and legislation) titles:

* Problems of evaluation and classification of reserves/resources of solid mineral raw materials

** Directive no. 3/1981 of the Czech Geological Office for evaluation and registration of geological prognoses and prognostic reserves of minerals

*** Mineral exploration and management of reserved deposit mineral reserves (proposal for analysis of the third part of the Mining Act)

**** Order of the Czechoslovak Socialistic Republic Government, on setting of standards, classification of reserves of reserved deposits and on assessing, approval and the State expertise of their estimates

***** Methodology enabling comparison of data of outdated methodology of deposit evaluation with newly proposed evaluation criteria according to PERC and JORC. – Certified methodology No. 2, project No. TB030MP013, TAČR Program Beta, Ministry of Industry and Trade. Prague.

MINERAL BASE OF THE CZECH REPUBLIC AND ITS DEVELOPMENT IN 2021

Petr Uldrych et al.
Ministry of the Environment of the Czech Republic

1. Legal framework for mineral resource use

1.1. Reserved and non-reserved minerals and their deposits

The minerals defined in Act No. 44/1988 Coll., on the Protection and Use of Mineral Resources (the Mining Act) as amended, are classified as being reserved and non-reserved. Natural accumulations of reserved minerals form reserved mineral deposits which constitute the mineral wealth of the country and are owned by the Czech Republic. Deposits of non-reserved minerals (especially sand and gravel, crushed stone and brick clay) are a constituent part of the land as stipulated in paragraph 7 of the Mining Act. The possibility to declare significant non-reserved mineral deposits as reserved deposits, was cancelled by the amendment of the Mining Act in 1991. Decisions of administrative agencies in this matter, which had been issued before the amendment went into effect, remain valid based on transitional provisions (paragraph 43 and 43a of the Mining Act). The deposits specified by these decisions are still reserved deposits, i.e. owned by the state, separated from the land itself.

1.2. Planning, approval and carrying out of mineral prospecting and exploration

1.2.1. Reserved minerals

Prospecting and exploration for reserved mineral deposits, by virtue of the ČNR Act No. 62/1988 Coll., on Geological Work (the Geological Act) as amended, may be conducted by an individual or organisation, providing that the work is managed and guaranteed by a qualified and certified person (certified responsible manager for the geological work). An organisation seeking to prospect for and explore these mineral deposits, to verify their reserves, and to process geological documents for their exploitation and protection, must make a request to the Ministry of the Environment to establish an exploration area. The proceedings, subject to administrative rules, are concluded by the establishment or non-establishment of an ‘exploration area’ (exploration permit). In the former case, the following must be determined: the survey area, the mineral to be prospected and explored for which the exploration area is being established, the conditions for the execution of the work, and the period of validity of the exploration area. The exploration area is not a territorial decision, but provides the entrepreneur or organisation (hereinafter “entrepreneur”) with the exclusive privilege to prospect for the mineral in a given exploration area. In the first year, the entrepreneur is obliged by law to pay a tax of CZK 2,000 per km² or km² piece of exploration area, which increases annually by CZK 1,000 per km² and its piece (to CZK 3,000 in the second year, to CZK 4,000 in the third year, etc.). These taxes represent an income for the municipalities, in whose cadastral areas the exploration area is established. If an exploration area lies on cadastral areas of more municipalities the income is divided after ratio of exploration areas on cadastral areas of individual municipalities.

Within the scope of planning and conducting the prospecting for and exploration of reserved mineral deposits, the organisation must consider the conditions and interests protected by special regulations (section 22 of the Act on Geological Work). These primarily refer to the laws for the protection of landscape and nature, agricultural and forest land; to the Water and Mining Acts etc. The Ministry of the Environment can cancel the established exploration area, if the organisation repeatedly or severely violates the obligations set by the Geological Act.

1.2.2. Non-reserved minerals (and their mining)

The above-mentioned enactments apply to prospecting and exploration for non-reserved mineral deposits, only, if they were previously declared as reserved deposits according to the transitional provisions of the Mining Act. In other cases, an organisation can prospect and explore for non-reserved minerals only upon agreement with the landowner. The provision under section 22 of the Act on Geological Work is also valid in these cases. The mining of non-reserved deposits, which constitutes a part of the land, an operation conducted according to the mining methods set by Act No. 61/1988 Coll., on Mining Operations, Explosives and the State Mining Administration, as amended.

1.3. Permit to mine a prospected and explored deposit

If, during prospecting and exploration, a reserved mineral is found to be of quality and quantity indicative of its accumulation (supported by a partial deposit reserve estimate given in the category of prospected reserves), the organisation must report it to the Ministry of the Environment, which issues a certificate for the reserved deposit owned by the state. At the same time, this certificate ensures the deposit against actions rendering its mining difficult or impossible by the establishment of a protected deposit area (CHLÚ) according to section 17 of the Mining Act.

The entrepreneur’s right to mine the reserved deposit is provided by the grant of a mining lease. The submittal of a proposal for the grant of a mining lease must be preceded by an approval from the Ministry of the Environment, which may depend on the fulfilment of limiting conditions accounting for the interests of the state mineral policy, and on covering expenses of geological work already funded by the state. The organisation, on whose behalf the exploration was carried out, has priority in receiving the approval for the grant of the mining lease. If it fails to assert its mining lease, precedence is then given to the organisation which participated financially in the exploration. Somewhat different rules apply to cases concerning crude oil and natural gas based on a transposed EU directive.

The mining lease is only granted to an entrepreneur possessing a Certificate of Mining Operations issued by an authorised Regional Mining Office. This grant procedure takes place in cooperation with relevant administrative agencies, mainly in agreement with environmental, land use planning and building authorities. The entrepreneur‘s proposal for the grant of a mining lease must be furnished with documentation as stipulated by law. The procedure deals with landowner relations and settlement of conflicts of interests, which are protected by special regulations. The environmental impact assessment (EIA) represents a part of the documentation, too. The grant of a mining lease represents a mining as well as land use authorisation.

The entrepreneur, who has been granted a mining lease, may start mining operations only after obtaining a mining permit from the authorised Regional Mining Office. The issue of this permit is subject to an administrative procedure assessing the plans of the opening, the preparation and the mining of the deposit, and the plans for rehabilitation and reclamation after termination of the mining. In justified cases, the Regional Mining Authority may combine the grant of a mining lease and of a mining permit into one administrative procedure.

1.4. Royalties on reserved minerals mined

The entrepreneur is obliged to pay royalties on the mining lease and the extracted reserved minerals. An annual lease payment of CZK 300 is assessed on every hectare opened within the

Royalty tariffs on extracted minerals for individual royalty bases

Mineral, group of minerals	Unit	Tariff for unit in CZK
Crude oil	m^3	558.00
Combustible natural gas	m^3	0.27
Uranium	t	5,834.13
Cesium	kg	160,782.00
Tin	t	22,726.00
Lithium	t	10,692.00
Manganese	t	2,308.00
Copper	t	7,115.00
Rubidium	kg	114,103.00
Tungsten	t	46,625.00
Golg	kg	40,919.00
Gemstones – moldavites	kg	1,939.59
Gemstones – garnets	kg	1,500.00
Gemstones – mass SiO_2	kg	10.00
Diatomite	t	4.95
Glass and foundry sand	t	8.24
Bentonite	t	3.32
Minerals used to stonework inclusive of fissile slates	m^3	17.55
Gypsum	t	21.84
Graphite	t	30.00
Technically utilisable mineral crystals	t	15.00
Ceramic and refraktory clays and claystones	t	34.74
Kaolin	t	30.00
Quartz, quartzite, dolomite, marl, basalt, phonolite, trachyte if the minerals are suited for technochemical or melting processing.	t	4.36
Feldspar	t	13.73
Wollastonite	t	5.00
High-purity limestone	t	10.55
Other limestones and corrective additives for cement production	t	3.25
Bituminous coal	t	9.90
Brown coal – opencast mining	GJ	1.18
Brown coal – underground mining	t	3.88
Crushed stone	m^3	2.91
Sand and gavel	m^3	3.39
Brick clays and related minerals	m^3	1.40
Other minerals	t	50.37

mining lease area, which is marked off on the surface. If there is permitted a mining activity in the mining lease consisting in the opening, the preparation and the mining of the reserved deposit this annual payment amounts CZK 1,000. The Regional Mining Authority fully transfers this payment to the municipalities, in whose territories the mining lease is located, according to the lease proportions in each municipal territory.

An annual royalties on minerals extracted in mining leases are given by the Government Provision no. 98/2016 Coll. from 16.3.2016, paragraph 33k, article 2 of the Mining Act in the wording of the Act 89/2016 Coll. amending the Mining Act no. 44/1988 Coll. on mineral protection and use.

The royalty is calculated as the product of royalty base, given by amount of mineral mined reported as net mine production in the mining lease, and the royalty tariff defined in Annex to the Government Provision no. 98/2016 Coll. for the mineral in question.

The Regional Mining Authority transfers the yielded royalties partly to the state budget of the Czech Republic to be purposefully used in remediation of environmental damage caused by the mining of reserved and non-reserved deposits, for the provision of discharge of the state geological service connected to protection and registration of mineral wealth and partly to the budget of the relevant municipalities. Portions of the state budget and the budget of the relevant municipalities differ for different minerals and are given by the Mining Act.

1.5. Reserves for mining damages and remediation during the mining of reserved minerals

During the course of mining, the entrepreneur is required to generate sufficient financial reserves for mining damages and for reclamation of areas affected by the deposit exploitation.

2. Selected statistical data on exploration and mining on the territory of the Czech Republic

Statistical data/year		2017	2018	2019	2020	2021
registered geological works [a]	total	6,225	7,718	6,122	6,137	5,376
	economic geological	11	18	24	28	17
protected deposit areas – number		1,123	1,147	1,154	1,161	1,156
mining leases – total number		968	960	960	959	952
number of exploited reserved deposits		506	501	497	491	487
number of exploited non-reserved deposits		203	173	170	178	179
mine production of reserved deposits, mill t [b]		109	114	110	100	103
mine production of non-reserved deposits, mill t [b]		12	12	13	14	15
organizations managing reserved deposits		326	333	304	305	302
organizations mining reserved deposits		180	173	172	171	153
organizations mining non-reserved deposits		147	157	132	132	105

Note: Numbers of data in view are given unless otherwise indicated

a) engineering-geological and hydrogeological works prevail

b) conversions: natural gas 1 mill m^3 = 1 kt, dimension and crushed stones 1,000 m^3 = 2.7 kt, sand and gravel and brick clays and related minerals 1,000 m^3 = 1.8 kt

3. Significance of mining in the Czech economy

Ratio/year	2017	2018	2019	2020	2021
Annual GDP* growth	5.2	3.2	3.0	1.4	6.99
Share of mining and quarrying in GDP, % of current prices	0.6	0.6	0.6	0.4	0.5
Share of mining and quarrying GVA in GVA of industrial production**, % of current prices	2.4	2.4	2.1	1.4	1.4

Source: Czech Statistical Office, own calculations
Notes:
* *GDP determined by production approach, volume indices, stable period of previous year = 100*
** *Industrial production = mining and quarrying + manufacturing + electricity + gas, steam and air conditioning supply*

4. Trends of reserves of minerals (economic explored disposable reserves)
Totals in mill t (if not otherwise stated)

Statistical data/year	2017	2018	2019	2020	2021
Metallic ores [a)]	92	92	95	95	95
Energy minerals [b)]	2,850	2,804	2,763	2,735	2,686
of which: uranium (U) (kt)	1	1	1	1	1
crude oil	21	22	22	22	21
natural gas [b)]	6	6	6	5	5
Industrial minerals	2,541	2,466	2,486	2,503	2,486
Construction minerals [c)]	5,174	5,154	5,153	5,161	5,178

Note:
[a)] *in 2015 Au ores (25 642 kt) and Li ores (860 kt), in 2016 Au ores (25 642 kt), Li ores (860 kt) and Sn-W ores (19 703 kt) ores, in 2017-2018 Au ores (25 642 kt), Li ores (860 kt), Sn-W ores (42 336 kt) and Mn ores (23 372 kt), in 2019-2020 Au ores (25 642 kt), Li ores (860 kt), Sn-W ores (42 336 kt) and Mn ores (26 495 kt)*
[b)] *natural gas – conversion into kt: 1 mill m^3 = 1 kt*
[c)] *moldavite bearing rock – conversion into kt: 1,000 m^3 = 1.8 kt*
[d)] *at reserved mineral deposits including dimension stone, conversion into kt – dimension and crushed stones 1,000 m^3 = 2.7 kt, sand and gravel and brick clays and related minerals 1,000 m^3 = 1.8 kt*

Generating of the financial reserves is approved by the Regional Mining Authority during the mining permit procedure regarding the opening and extraction of the deposit. Drawing on the reserves is permitted by the Regional Mining Authority upon agreement with the Ministry of the Environment and upon notification by the relevant municipality. In the case of (partially) state-owned enterprises, the Regional Mining Authority decides in agreement with the Ministry of Industry and Trade.

5. Summary of exploration licences valid in 2021 and newly issued in 2021 (listed according to minerals) – prospecting and exploration works financed by companies

Minerals and underground placement sites	Number of valid EA (min. 1)	Number of valid EA (min. 2)	Number of new issues in 2021	Start of validity in 2021
Bituminous coal	–	–	–	–
Crude oil and natural gas	21	–	–	–
Sn-W and Li ores	6	–	–	–
Li ore	–	6	–	–
Cu ore	–	2	–	–
Graphite	–	–	–	–
Gemstones	4	–	–	–
Kaolin	10	–	1	1
Clays	7	–	1	1
Bentonite	5	–	–	–
Feldspar and feldspar substitutes	17	–	–	–
Silica raw materials	3	–	–	–
Corrective additives for cement production	–	–	–	–
Dimension stone	1	–	–	–
Crushed stone	1	–	1	1
Sand and gravel	8	–	–	–
Underground placement sites, underground reservoirs	5	–	–	–
Total	**88**	**8**	**3**	**3**

EA – exploration area
Mineral 1 (min. 1) – in case that the raw material is the major one
Mineral 2 (min. 2) – in case that the raw materials is a by–product

6. State-funded geological projects

6.1. Economic geology projects

The Central Geological Authority of the state administration fulfils the duty involving the state register of reserved deposits – state property (section 29 of the Mining Act). Accordingly, it issues the register as one of the main sources for

- land use planning
- the raw material policy
- the energy policy
- the environmental policy

- the structural policy
- the employment policy

The register lists the latest status of the deposits as documented in the reserves estimate. The reserves estimate is prepared with respect to the conditions of exploitability expressing

- the state of the market, prices, business economy,
- the mining and technical conditions of exploitation,
- the conflicts of interests arising from the deposit exploitation (primarily environmental protection and other conflicts)

It is altogether entirely unstable factors reflecting political, economic and social change (in the largest sense).

In the area of economic geology, the processing of updated data bases of the publication Mineral commodity summaries of the Czech Republic 2021 was carried out and at the same time the electronic passportisation of deposits and exploration areas continued (Deposit Information System LIS). Areas of prognostic resources of moldavites (category Q) were delimited in the South Bohemian Basins.

Expenditures for state-funded exploration work related to economic geology (rounded values)

1993	CZK	248.7 mill	2008	CZK	9.9 mill
1994	CZK	249.8 mill	2009	CZK	10.1 mill
1995	CZK	242.3 mill	2010	CZK	4.2 mill
1996	CZK	163.0 mill	2011	CZK	4.0 mill
1997	CZK	113.2 mill	2012	CZK	1.0 mill
1998	CZK	114.2 mill	2013	CZK	1.5 mill
1999	CZK	110.8 mill	2014	CZK	0.7 mill
2000	CZK	26.3 mill	2015	CZK	0.7 mill
2001	CZK	21.5 mill	2016	CZK	1.7 mill
2002	CZK	17.0 mill	2017	CZK	0.9 mill
2003	CZK	7.0 mill	2018	CZK	1.0 mill
2004	CZK	26.2 mill	2019	CZK	1.0 mill
2005	CZK	12.0 mill	2020	CZK	0.7 mill
2006	CZK	1.7 mill	2021	CZK	1.1 mill
2007	CZK	3.0 mill			

6.2. Other geological projects

Mainly geological work of a non-economic geology character was funded by the state. Individual projects were publicly commissioned in order to implement the following partial programmes:

- geological informatics
- geological mapping
- geohazards of the environment
- hydrogeology
- engineering geology
- comprehensive geological studies

The following expenditures were spent on these geological projects since 1998:

1998	CZK	29.6 mill	2010	CZK	35.0 mill
1999	CZK	39.2 mill	2011	CZK	22.8 mill
2000	CZK	48.5 mill	2012	CZK	12.6 mill
2001	CZK	72.8 mill	2013	CZK	8.2 mill
2002	CZK	61.0 mill	2014	CZK	7.5 mill
2003	CZK	67.0 mill	2015	CZK	9.2 mill
2004	CZK	52.1 mill	2016	CZK	9.0 mill
2005	CZK	60.3 mill	2017	CZK	8.8 mill
2006	CZK	55.4 mill	2018	CZK	8.7 mill
2007	CZK	58.1 mill	2019	CZK	8.6 mill
2008	CZK	41.0 mill	2020	CZK	8.9 mill
2009	CZK	42.2 mill	2021	CZK	8.5 mill

7. Summary of selected legal regulations on mineral prospecting and exploration in force as of June 30, 2022

7.1. Acts

Act No. 44/1988 Coll., on mineral protection and use (the Mining Act) – as amended by the Acts No. 541/1991 Coll., No. 10/1993 Coll., No. 168/1993 Coll., No. 132/2000 Coll., No. 258/2000 Coll., No. 366/2000 Coll., No. 315/2001 Coll., No. 61/2002 Coll., No. 320/2002 Coll., No. 150/2003 Coll., 3/2005 Coll., No. 386/2005 Coll., No. 186/2006 Coll., No. 313/2006 Coll., No. 296/2007 Coll., No. 157/2009 Coll., No. 227/2009, Coll., No. 281/2009 Coll., No. 85/2012 Coll. , No. 350/2012 Coll., No. 498/2012 Coll., 257/2013 Coll., No. 89/2016 Coll., No. 264/2016 Coll., No. 183/2017 Coll., No. 225/2017 Coll., No. 403/2020 Coll., No. 609/2020 Coll. And No. 88/2021 Coll.

Act No. 61/1988 Coll., on mining operations, explosives and the state mining administration as amended by the Acts No. 425/1990 Coll., No. 542/1991 Coll., No. 169/1993 Coll., No. 128/1999 Coll., No. 71/2000 Coll., No. 124/2000 Coll., No. 315/2001 Coll., No. 206/2002 Coll., No. 320/2002 Coll., No. 226/2004 Coll., No. 3/2005 Coll., No. 386/2005 Coll., No.186/2006 Coll., No. 313/2006 Coll., No. 342/2006 Coll., No. 296/2007 Coll., No.376/2007 Coll., No.124/2008 Coll., No.274/2008 Coll., 223/2009 Coll., No. 227/2009 Coll., No. 281/2009 Coll., No. 155/2010 Coll., No 184/2011 Coll. , No. 18/2012 Coll., 64/2014 Coll., No. 250/2014 Coll., No. 206/2015 Sb., No. 204/2015 Sb., No. 320/2015 Coll., No. 91/2016 Coll., No. 243/2016 Coll., No. 451/2016 Coll. and No. 183/2017 Coll., 91/2018 Coll., No. 403/2020 Coll., No. 609/2020 Coll., No. 261/2021 Coll., and No. 284/2021 Coll.

Act No. 62/1988 Coll., on geological work, as amended by the Acts No. 543/1991 Coll., No. 366/2000 Coll., No. 320/2002 Coll., No. 18/2004 Coll., No. 3/2005 Coll., No. 444/2005 Coll., No. 186/2006 Coll., No.124/2008 Coll., No. 223/2009 Coll., No. 227/2009 Coll., No. 281/2009 Coll., No. 85/2012 Coll., 64/2014 Coll., 183/2017 Coll. and 225/2017 Coll.

Act No. 157/2009 Coll., on mining waste treatment and amendment of some acts, as ammended by the Act No. 168/2013 Coll., No. 183/2017 Coll., No. 225/2017 Coll. and 609/2020 Coll.

Act No. 85/2012 Coll., on carbon dioxide capture into natural rock textures and on amendment of some acts, as amended by the Acts No. 383/2012 Coll. and No. 64/2014 Coll., 193/2016 Coll., 183/2017 Coll. And No. 609/2020 Coll.

Act No. 158/2000 Sb., on prospecting, exploration and exploitation of sea bottom mineral resources and on safety of crude oil and natural gas operations in sea, as amended by the Act No. 296/2007 Coll., No. 124/2008 Coll., No. 227/2009 Coll., No. 281/2009 Coll., No. 201/2015 Coll and No. 183/2017 Coll.

7.2. Other legal regulations

7.2.1. Mineral deposits exploitation

Decree of the ČBÚ No. 104/1988 Coll., **on efficient use of reserved deposits, on permits and notification of mining operations and other activities employing mining methods,** as amended by the Decree No. 242/1993 Coll., No. 434/2000 Coll., and No. 299/2005 Coll.

Decree of the ČBÚ No. 415/1991 Coll., **on construction, the elaboration of documentation and the determination of safety pillars, rods and zones for the protection of underground and surface sites** in the wording of the Decree of the ČBÚ No. 340/1992 Coll., and No. 331/2002 Coll.

Decree of the ČBÚ No. 172/1992 Coll., **on mining leases** in the wording of the Decree No. 351/2000 Coll.

Decree of the ČBÚ No. 175/1992 Coll., **on the conditions of non-reserved mineral deposit exploitation** in the wording of the Decree No. 298/2005 Coll.

Decree of the MŽP ČR No. 363/1992 Coll., **on the survey and registry of old mine workings** in the wording of the Decree of the MŽP No. 368/2004 Coll.

Decree of the MŽP ČR No. 364/1992 Coll., **on protected deposit areas**

Decree of the ČBÚ No. 435/1992 Coll., **on mine surveying documentation during mining and during some operations employing mining methods** in the wording of the Decree of the ČBÚ No. 158/1997 Coll., the Decree No. 298/2005 Coll. and the Decree No. 382/2012 Coll.

Government Provision No. 98/2016 Coll.**, on the royalty tariffs** (of mined out minerals)

Decree of the MPO No. 29/2017 Coll.**, on mining technical records**

7.2.2. Geological work

Decree of the MŽP No. 282/2001 Coll., **on the registration of geological work**, in the wording of the Decree of the MŽP No. 368/2004 Coll.

Decree of the MŽP No. 368/2004 Coll., **on geological documentation**

Decree of the MŽP No. 369/2004 Coll., **on the planning, execution and evaluation of geological work, on announcing geohazards, and on the procedure for estimating reserves of reserved deposits** as amended by the Decree of the MŽP No. 18/2009 Coll.

7.2.3. Regulations on licensing of mining operations and verification of qualification

Decree of the ČBÚ No. 298/2005 Coll., **on the requirements for professional qualification and competence in mining or operations employing mining methods, and on some legal regulation changes,** in the wording of the Decree No. 240/2006 Coll. and the Decree No. 378/2012 Coll.

Decree of the ČBÚ No. 15/1995 Coll., **on the licensing of mining operations and operations employing mining methods as well as on the development of sites and installations, which constitute these operations,** in the wording of the Decree No. 298/2005 Coll. and the Decree No. 380/2012 Coll.

Decree of the MŽP ČR No. 206/2001 Coll., **on the certificate of qualification for planning, executing and evaluating geological work**

ECONOMY AND MINERALS

Foreign direct investment in mining in the Czech economy

Foreign direct investment (FDI) is an investment of money or money assessable assets and rights made by a company or individual in one country in business interests (e.g. agreement on profit distribution, excercise of effective influence on a company business, minimum stake 10% in a company equity, in a company voting rights) in another country in order to gain share in the business.

FDI = equity (investment of foreign investor into a company equity also equity of branches, daughter and associate companies)
+ reinvested profit (= retained profit of past periods + post-tax profit – dividends)
+ other capital (given and taken credits and debt securities among direct investors and their branches, daughters and associate companies)

Compiled on the basis of the texts:
Foreign Direct Investment – FDI.-(I)INVESTOPEDIA, www.investopedia.com/terms/fdi.asp
Bolotov I. (2015): Diskuse na téma přímé zahraniční investice a a) jejich obecné dopady na Českou ekonomiku b) jejich dopady na strukturu zapojení České republiky do mezinárodního obchodu. 2M0301 „Mezinárodní obchod“, cvičení č.9. – Katedra mezinárodního obchodu, Fakulta mezinárodních vztahů, VŠE, Praha.

Following tables are based on CNB data and own calculations.

Foreign direct investment in the Czech Republic – state on the date December 31 of the given year (ths CZK unless provided otherwise)

		FDI total	In mining and processing of bituminous and brown coal	In extraction of crude oil and natural gas	In other mining	In supporting activity in mining total	Total in mining activities	Total in mining activities as % of FDI total
2016	Equity	1,569,048,217	11,071,231	1,636,785	3,173,462	81,980	15,963,458	1.02
	Reinvested profit	1,310,028,377	–10,037,497	3,706,865	4,246,086	1,460,430	–624,116	–0.05
	Other capital	245,154,046	1,711,341	–1,594	450,777	–80,547	2,079,977	0.85
	Total	3,124,230,640	2,745,075	5,342,056	7,870,325	1,461,863	17,419,319	0.56
2017	Equity	1,658,868,518	11,065,886	2,000,260	3,166,623	49,746	16,282,515	0.98
	Reinvested profit	1,412,506,549	–13,219,180	5,203,427	3,558,423	355,695	–4,101,635	–0.29
	Other capital	249,895,999	1,617,600	–73,241	608,660	–6,314	2,146,705	0.86
	Total	3,321,271,066	–535,694	7,130,446	7,333,706	399,127	14,327,585	0.43
2018	Equity	1,777,308,973	11,067,039	1,967,942	3,120,295	19,746	16,175,022	0.91
	Reinvested profit	1,538,676,507	–11,878,808	5,350,665	3,653,677	311,780	–2,562,686	–0.17
	Other capital	373,483,090	–16,960	2,378	721,514	–3,761	703,171	0.19
	Total	3,689,468,570	–828,729	7,320,985	7,495,486	327,765	14,315,507	0.39
2019	Equity	1,895,463,899	11,079,777	1,734,419	3,053,555	19,746	115,021	0.01
	Reinvested profit	1,574,898,431	–12,661,050	5,122,983	3,821,021	313,014	309,410	0.02
	Other capital	405,378,216	–16,960	–748	675,286	–3,761	2,821	0.00
	Total	3,875,740,546	–1,598,233	6,856,654	7,549,862	328,999	427,252	0.01
2020	Equity	1,855,120,519	11,079,777	2,358,330	3,053,555	19,746	16,511,408	0.89
	Reinvested profit	1,700,690,103	–12,531,560	5,316,271	3,791,958	312,275	–3,111,056	–0.18
	Other capital	465,981,592	–16,960	–5,067	675,286	–3,761	649,498	0.14
	Total	4,021,792,214	–1,468,743	7,669,534	7,520,799	328,260	14,049,850	0.35
2021*	Equity	2,339,446,353	11,127,365	2,398,620	3,907,182	27,830	17,460,997	0,75
	Reinvested profit	1,608,799,545	–11,867,331	5,071,659	4,492,336	284,555	–2,018,781	–0,13
	Other capital	454,837,437	0	498	–298,263	0	–297,765	–0,07
	Total	4,403,083,335	–740,016	7,470,777	8,101,255	312,385	15,144,401	0,34

* *preliminary data*

Foreign direct investment of the Czech Republic origin abroad – state on the date December 31 of the given year (ths CZK)

		FDI total	In mining and processing of bituminous and brown coal	In extraction of crude oil and natural gas	In other mining	In supporting activity in mining total	Total in mining activities	Total in mining activities as % of FDI total
2016	Equity	–	0	0	182,961	0	182,961	0.06
	Reinvested profit	202,345,248	0	0	199,935	0	199,935	0.10
	Other capital	–17,541,072	0	0	–553	0	–553	0.003
	Total	498,070,982	0	0	382,343	0	382,343	0.08
2017	Equity	345,296,757	0	0	191,655	0	191,655	0.06
	Reinvested profit	334,332,372	0	0	121,519	0	121,519	0.04
	Other capital	9,433,924	0	0	0	0	0	0.00
	Total	689,063,053	0	0	313,174	0	313,174	0.05
2018	Equity	476,945,220	0	0	404,039	0	191,655	0.04
	Reinvested profit	383,617,076	0	0	322,281	0	112,480	0.03
	Other capital	60,618,976	0	0	0	0	0	0.00
	Total	921,181,272	0	0	726,320	0	726,320	0.08
2019	Equity	507,292,707	0	249,795**	0	0	249,795	0.05
	Reinvested profit	472,888,590	0	154,112**	0	0	154,112	0.03
	Other capital	40,808,577	0	104**	0	0	104	0.0003
	Total	1,020,989,874	0	404,011**	0	0	404,011	0.07
2020	Equity	516,239,684	0	249,795**	0	0	249,795	0.05
	Reinvested profit	546,529,185	0	140,511**	0	0	154,112	0.03
	Other capital	31,156,826	0	104**	0	0	104	0.00
	Total	1,093,925,695	0	390,410**	0	0	404,011	0.04
2021*	Equity	605,483,460	0	0	0	0	0	0,00
	Reinvested profit	441,734,753	0	0	0	0	0	0,00
	Other capital	129,494,133	0	0	0	0	0	0,00
	Total	1,176,712,345	0	0	0	0	0	0,00

** preliminary data*

*** FDI in extraction of crude oil and natural gas and in supporting activity in mining total*

Aggregate deposits in the Czech Republic

Josef Godány

Crushed stone

Crushed stone (CS) is along with sand and gravel generally referred as the aggregate. Sufficient available resources of construction raw materials, in particular CS (crushed stone – crushed aggregates) are needed to develop transport infrastructure, including modern railway corridors and a motorway network. For projects to be ecologically and economically viable it is desirable that the necessary raw materials of suitable quality are as close as possible to the sites of transport structures. The environmentally viable use of local deposits is beneficial to environmental protection as it minimizes the transport of raw materials over long distances. In connection with the gradual use and extraction of existing CS deposits – i.e. for deposits already worked by mining activities (MA) as part of the developing, preparing and mining plan (DPMP) and in the zoning decision according to the activities carried out by mining method (ACMM) – usually a procedure of several years can be considered from preparing the project to mining. Although further expansion or continuation of mining is approached with a reasonable time perspective, until now the Czech Geological Survey (CGS) records projects that have long been solved/prepared for 7 to 12 years with an unclear result. In no case is it immediately possible to use other new resources or continue mining on existing deposits only after the existing deposits are exhausted. For about 30 years, no new stone quarry has been opened in the Czech Republic. Without further extending the existing mining activities or providing the authorization for opening a new aggregate deposit it is not possible to ensure sufficient production of the assortment of adequate quality covering the demand and the need for CS in individual regions, especially near already completed or planned line structures of state or regional importance.

Of the total 322 registered exclusive deposits of CS only 177 were active in 2021 in the Czech Republic, i.e. with mining authorization, and 49 of the total 216 non-reserved mineral deposits had mining authorization. In total there are 225 active stone quarries in the Czech Republic (but only 207 active and reporting production) and their total annual production of CS was 16.6 million m^3 in 2021. The Czech Republic has seemingly large amounts of geological reserves of CS (2,487 bill. m^3) but the volumes of reserves that can be mined are significantly lower (they amount to just over 28% of the total geological reserves) and the reserves with permitted mining are even lower (they amount to less than 23%). The production and consumption of CS has been growing significantly over the last ten years (in 2012 – 12.1 mill. m^3, in 2021 – 16.6 mill. m^3). The price of construction aggregates are thus rising significantly (on average by CZK 26-35 per ton over the last year). Moreover production fractions of 0/4, 2/4, 2/5 and 4/8 mm are insufficient for the small crushed aggregate (SCA) and production fractions 8/11, 11/16, 16/22, 8/16, 16/32 and 32/63 mm are insufficient for the coarse crushed aggregate (CCA), in particular adequate crushed-run rock for railway beds complying with B0 class. In the medium and long term, the construction and construction material industries have sufficient reserves of production capacity, but the real availability of stocks of input raw materials that are being reduced at a high pace can pose a problem. The consumption of construction materials is generally proportional to the standard of living, i.e. the economic maturity of the state. The requirements for quality and volume of output assortments of construction materials are increasing significantly. The CA (crushed aggregates) production fractions SCA 0/4 mm, 2/4 mm, 2/5 mm and 4/8 mm and the CCA production fractions 8/11 mm, 11/16 mm, 16/22 mm, 8/16 mm, 16/32 and 32/63 mm, especially prime gravel and grit for track beds and ballast beds are becoming very expensive and their supplies are critical.

Since 1989 no new CS deposits have been opened, except some initially local sand ponds for sub-base and backfill materials that were later technologically rebuilt to high-capacity sand and gravel plants producing prime concrete and mortar gravel and sand. Unlike stone quarries, where no new deposits were opened, new sand pits were launched. Most of these deposits have been exploited for a long time, and it is logical that the stocks of raw materials are gradually being mined out. These deposits were mainly developed within defined mining claims (MC) according to the possibilities of gradual expansion and deepening to the extent of the applicable decision until the maximum economical exhaustion of all stocks. Since about 1993 along with mining in reserved deposits of construction raw materials the importance of mining in non-reserved mineral deposits has been gradually increasing as part of planning permits that currently produce high amounts of prime concrete sands and ballast annually and are starting to have a significant share in the total production of construction raw materials in the Czech Republic. Unfortunately, these resources are being gradually exhausted, and new resources for planned use are encountering major issues. Overall, according to the latest statement of the Road And Motorway Directorate of the Czech Republic (RSD) there is clearly a lack of high-quality CCA for asphalt mixtures, a lack of suitable fraction 0/4, 2/4, 4/8 and 8/16 mm for concrete, a combination of many different aggregates in asphalt mix is critical, the necessary amounts of high-quality aggregate for asphalt mixing plants and concrete mixing plants are not secured. The number of complaints and the price of work is also increasing in proportion to the decrease in high-quality natural aggregates. The Road And Motorway Directorate of the Czech Republic is recording an increasing number of complaints, currently there are dozens of transport constructions, i.e. their number increased of around 30% in 2021 compared to previous years. One of the main reasons is that high-quality aggregates are declining. More and more situations are occurring where the supplier must mix aggregates from two or more resources to meet the required quality parameters resulting in increasing logistic demands and the resulting costs of work and the final cost of raw materials significantly. There is an increasingly difficult situation with providing supplies for construction material production plants (concrete mixing plants, asphalt mixing plants) with aggregates, especially the increasing lack of aggregates, production capacity of quarries and sandpits, difficulties with approving asphalt mixture recipes in the RSD CR laboratories in Prague (namely, "type tests" – hereinafter the TT) and supporting tests of concrete (see Ing. Jiri Skrabka, Department of Quality Control of Buildings of RSD). Concrete production is facing a similar situation – formulas involving substituting aggregates from another resource are more often approved. According to the RSD CR laboratories the lack of aggregates is shown by a growing number of identical types of approved mixtures for asphalt mixing plants being presented, differing only with the aggregate (instead of one usual source for both SCA and DDK a large asphalt mixing plant must be supplied from two sources for SCA and even from three quarries for CCA. Moreover all SCA and CCA sources may not even be identical). This results in approving unnecessary quantities of identical asphalt mixtures with different by the shortage forced aggregate fraction batches from various quarries (one is the 4/8 fraction from quarry ‘A’, the other is CCA from quarry ‘B’, or the type test includes CCA from quarries ‘A to C’…). In proportion to this, the risk of replacing accidentally aggregates or even the risk of CCA deliberate replacement (in order not to stop production) increases. The situation is particularly critical with the 8/11mm fraction. Today this mostly involves the SMA 11 asphalt mixture which usually contains about 46%– 55% of this fraction with other fractions proportion being significantly lower. So far an asphalt mixing plant has been using aggregates from two to three sources (filler (ground limestone) from one quarry, CCA + SCA from another one, or, exceptionally, from the third source – little of CCA from a sandpit), this proven supply scheme is changing in many asphalt mixing plants. This leads to price increases of (not only) aggregates, their permanent shortage, in particular the chronic shortage of certain fractions, the unequal position between the quarry and its customers, pressures on the highest possible quarry production that on the other hand is reflected in failing to meet the prescribed aggregate gradation and complaints about quarries. The grain-size issue includes mainly the following aspects:

Current state of development of individual crushed stone deposits in relation to the mining volume limits on individual mining benches:

- Verified physical-mechanical properties of the rock, e.g. according to the criteria of complying with the parameters defined by the standard requirements of ČSN EN for individual construction purposes.
- Deposit parts excluded from mining due to their high content of overlying loam, demanding cleaning and unsuitable technological properties (railway gravels 0-32 mm A, 32-63 mm B1, B0, in particular the rate of absorption, frost resistance, LA abrasion hardness, cube strength, polished stone value (PSV).
- Selection of deposit parts that only meet the main criteria for the applicability of rock for the most demanding construction purposes (producing bituminous and concrete mixtures, mechanically reinforced aggregate (MRA)).

• Variability of technological operations within the entire aggregate treatment procedure and the plant´s technological facilities plus an option of implementing auxiliary technologies involving mobile aggregate treatment plants.

The most important for these purposes are:

- Composition and type of production equipment, their disposition for the given production purpose, determining the number and type of individual sections (e.g. number of stages of crushing and sorting, also according to the type of rock and its physical-mechanical and technological parameters)
- Compliance with technological discipline and calculating the treatment plant capacity
- Optimising the technological parameters of the production process
- The peak and average production breakdown characterized by the output grain characteristics and the percentage of individual granular fractions of aggregate intended for final sorting – fine production in the range of, for example: 0-22 mm with the following range (0-2 mm, 2-5 mm, 5-8 mm, 8-11 mm, 11-16 mm, 16-22 mm). This range allows some variability in the production process settings and cannot be changed excessively. At the customer output, each fraction has a certain percentage ratio in the grain curve.

The differences therefore mainly depend on the technological equipment of the production line and any variability in the setting of the whole production process. So the overall possibilities in the production breakdown are limited by the equipment and the setting of the line. Furthermore by the time use during the current year and available time for the quarry production (single-shift or dual-shift operation or their combination, adding Saturdays and Sundays as possible, depending also on prohibitions of production around municipalities and the relevant decrees).

- The structure and requirements for the material composition from customers and the timing of their placing on the construction market where they will be consumed

And at this point the production possibilities of individual quarries and the requirements of the construction market over a certain time and the composition of the desired assortment are in conflict. If a quarry supplies several asphalt mixing plants and concrete mixing plants and they have concurrent requirements, it usually fails to meet them because of the production breakdown so it usually cannot be delivered, precisely because of this reason.

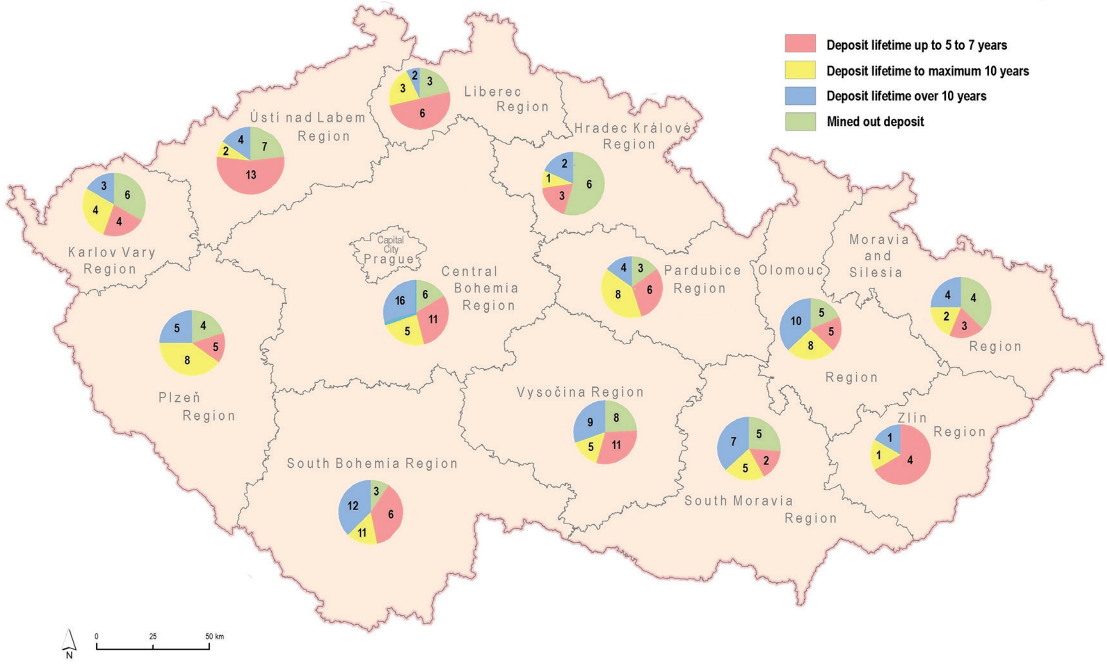
Asphalt mixing plants cannot fully rely on the supply from one quarry, they must ensure additional sources but they do not always manage to conclude a contract to supply the necessary quantity of aggregates, and ensuring supplies over the contracted quantities is always a problem.

Firms that do not have their own asphalt mixing plants face a problem with securing the supply of asphalt mixture in some places (the quarry is not able to increase supplies for the plant so an asphalt mixing plant in areas with high construction activities does not have any extra capacity). This results in transporting mixtures over longer distances, unnecessary destruction of roads by heavy vehicles, environmental damage due to the high temperatures needed to produce asphalt mixtures transported over longer distances, a greater risk of insufficient compaction of the asphalt mixture cooled during long transport. This unsatisfactory situation on the aggregates market has a detrimental impact on the national level.

A “primary” extracted and crushed aggregate from sandpits and quarries is usually used to produce asphalt and concrete mixtures designed for the most heavily loaded upper road surfaces. To comply with the strict requirements of the relevant CSN EN standards the extensive existing and planned construction activities carried out on the new road infrastructure and to repair existing motorways and category one roads (e.g. modernizing D1 highway, constructing D3, D7, R6, D49, D55, D35 highways and other important road construction projects) require more and more high-quality extracted and crushed aggregates, of which however there are more and more shortages on the market. Only the road and rail infrastructure that was built using high-quality aggregates can be safe, mechanically strong and durable.

The 32/63 mm grain fraction BI class railway ballast aggregate has very specific requirements and not every quarry can produce it. Some quarries have a certificate for the 0/32 mm fraction, but do not have a certificate for the BI class 32/63 mm fraction. This is caused mainly because the crushed 32/63 mm fraction class BI aggregate must meet the very strict criterion in the impact crushability and crushing resistance test. Moreover, not the entire deposit but only some parts of it meet these strict criteria. Therefore, each issued certificate always states precisely specified deposit parts which meet the requirements to guarantee the maximum possible quality of the aggregate. These very strict quality conditions are laid down by the relevant regulation – the new General Technical Conditions (GTC), “Aggregates for railway ballast” which replace the GTC ref. no. 59110/2004-O13 in the wording of Amendment No. 1, ref. No. 23155/06-OP effective as of August 1st, 2006 – and these are intended to ensure the long life span of the aggregate in railway constructions. If these parameters were not observed the aggregate is at risk of degenerating and the safety of the operated tracks is compromised.

Number and service life of mined and mined out crushed stone deposits in the regions of the Czech Republic



Another aggregate class that will be used in the near future for railway structures is the B0class 32/63 mm fraction. It is the aggregate used in high-speed tracks. In the Czech Republic high-speed construction railway projects with a design speed of 350 km/h are already being prepared. The B0 class 32/63 mm aggregate fraction will needed for all lines from 200 km/h to 350 km/h. The currently proposed criteria have not been approved yet, it is a draft. Also the number of quarries that meet the new requirements for class B0 is not even known. Anyway the requirements for this aggregate will be enormous since only new crushed aggregate is acceptable for safe operation at high speeds. Only 8 quarries with an annual production capacity of 110 thousand tons of high-quality BI class raw material (in the best case B0) meet the current strict criteria for the use of high-quality crushed aggregates when constructing railway corridors which will be part of the European railway network in the Czech Republic (source: Ing. Jan Čihák, SŽ, p.: Amendment to GTC Aggregates for railway ballast, estimate aggregate consumption, 2019). In this context, it should also be noted that this fact represents the current state of affairs given the mining progress and readiness of quarries to extract these reserves of stone. Not always when developing individual mining sites does the raw material outside the already excluded technologically unsuitable parts show the constant physical-mechanical parameters across the entire mining profile and the extraction course. In this respect the supply of aggregates for this sector can also be very problematic.

Other factors that will directly affect the actual implementation and delivery of these railway construction materials can particularly include an excessive transport load at the sites intended for supplying current and future construction projects concentrated from a small number of mining sites (sometimes even a single one) for even relatively long distances with significant loss of these natural resources. Furthermore the availability of loading sites for ballast gravel and adequate facilities, i.e. branch lines, shuttle transport to railheads, intermediate loading, bulk storage in one place, complicated operation on secondary lines due to the disconnection of complete trains, the requirements of railway construction for large amounts of materials over a short period of time (line closures, expensive handling and working machines for operations in structural layers of the track bed), the requirements for aggregates from one supplier for the entire section (variety of aggregates, i.e. basalts, greywackes, granites, etc.) and last but not least the production technology equipment allowing the production of the 32/63 mm fraction aggregates for track superstructure, and the 0/32 mm fraction for the track substructure in the required time. The accessibility of the production process breakdown using at least the required two-stage crushing is about 40% of the 32/63 mm fraction and 60% of the 0/32 mm fraction. On average one standard meter of a single-track railway body requires 4 tons of aggregate for the track superstructure and 4 tons for the track substructure.

Each quarry has a different petrographic character, quality and also technological-processing facilities, extraction conditions, geological and structural conditions as well as territorial environmental conditions. Not every quarry produces the same quality of raw material with the identical petrographic type, therefore their production is different and their use on the market as well. The physical-mechanical properties of rocks greatly affect the demand factor of grinding processes when treating mineral resources. The most important physical-mechanical properties include the crushability and abrasiveness of the material being processed. The Wi work index and Ai abrasion index are very important criteria in deciding and choosing the method of crushing. Inappropriate technology can significantly affect the overall processing costs, in particular energy costs and the cost of exchanging machinery action elements. The characteristics of aggregates are specified in the relevant ČSN EN standards. They involve a group of characteristics which are inherent to a rock and whose changes are beyond the real possibilities of aggregate suppliers both financially and technically. In particular they include sulphur content, frost resistance, durability, rate of absorption, strength, polished stone value, Micro-Deval abrasiveness, impact crushability, soft grains, foreign particles of mineralogical nature and partly also crushing resistance.

Not every petrochemical type of rock from crushed and extracted aggregate can be used for example in high-strength and construction concretes or in coated asphalt mixtures, etc. For example crushed limestone is therefore particularly suitable for the underlying films, especially when it meets the requirements specified in section 5.2 of Article 5 Rough aggregate's crushing resistance, Article 5.5 Rate of absorption, and Article 7.3 Resistance to freezing and defrosting according to ČSN EN 13242 + A1 (Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction), and ČSN EN 13285 (Unbound mixtures – Specifications). Crushed stone from sedimentary limestone is not used in construction concrete in the Czech Republic. Crushed limestone is absolutely not allowed to be used as an aggregate for railway ballast, and in particular for structural concrete because of the potential content of unwanted rocks and minerals (hornstone and SiO_2), which are susceptible to ASR (alkali-silica reaction). Aggregates, especially those used in concrete, are monitored for their resistance to ASR.

The aggregates used in asphalt technologies are monitored for the adhesion of the bonding agent (asphalt) to the aggregate to determine if additives need to be added to the mixture. The adhesion of asphalt to the aggregate decreases with decreasing alkalinity in approximately the following order: limestone → dolomites → basalts → gabbro→ greywackes → phonolites → diorites → granites → ryolites → porphyries, and porphyrites.

Currently resources of construction raw material deposits licensed for extraction are getting smaller and smaller. A large part of the reserved deposits of non-reserved raw materials are approaching their completion. While the share of recycled products is increasing these are not suitable for standard applications in the linear infrastructure. The required technological characteristics cannot be achieved with these recycled products. Recycled products can be effectively used as an auxiliary material for multiple constructions, but not as the main material. Increasing the share of recycled materials at construction sites is an important aspect due to the growing focus on the circular economy. However, the amounts of recyclates produced from construction and demolition waste are not sufficient. The gradual substitution of primary mineral raw materials by recyclates has certain limits because many applications in the construction sector require high-quality aggregate from primary sources (e.g. high-strength concrete, railway ballast superstructure, etc.). Following recycling the aggregate must meet the technical requirements for gradation, small particle content, fine particle content, grain shape, edge rounding, the content of foreign particles as well as the tests for strength, rate of absorption, resistance to freezing, the proportion of shale grains, the breakdown of basalt. This is because of the precondition of maintaining the original mechanical-physical properties which should be constant. Overall, the technological characteristics of recycled materials in some aspects also cannot meet the requirements for natural materials (e.g. compressive strength, crushing resistance, rate of absorption, resistance to freezing, etc.) and thus their use is significantly reduced. Technological treatment and hygienic analysis of construction and demolition waste (C&D) is extremely demanding and significantly increase the cost of recycled materials and, as a result, its use on the market is more limited compared to primary sources. Another problem with recycling from C&D waste and railway ballast aggregates is that they are more energy demanding than extracting and treating CS, in particular because of high water consumption. Especially at this time when water consumption is growing but its resources are declining rapidly because of the climate change. For recycled C&D waste material it is essential to check the leachability, to carry out sampling by an independent entity, and to introduce a mandatory sampling frequency. Moreover, the aggregate obtained from railway ballast can only be recycled long-term if the actual gradation and the shape index, crushing resistance, abrasion resistance and strength characteristics comply with the strict quality and technological requirements and properties of class B0 and BI, or BII. More often however is the process of crushing aggregates to a smaller fraction that can be used as a track substructure´s structural layer, as an underlying layer of road structures, or as a gravel pack for sealing landfills or for ground reclamation. In practice, the original "gravel" from the ballast bed of refurbished railway lines has been used for many years, at best only from about 60–70% and exclusively on the track substructure of the 0/32 mm fraction layer on completely new construction projects. However the 32/63mm fraction recyclate from the railway ballast superstructure is not applied retrospectively, this application requires a 100% fresh primary raw material from the quarry, just like about 30% of the whole new 0/32mm fraction for the railway ballast substructure. The rest of the 32/63mm and 0/32mm pre-crushed fractions are used for CCA in road construction or concrete, and – in particular – the waste.

Sand and gravel

The gradual depletion of available sand and gravel resources and the worrying state of affairs is highlighted by the currently finalized background material of the Ministry of Industry and Trade (MIT) for the application of the State Raw Material Policy under the title "Study of the evaluation of the current state and perspective of the use of building raw materials in the Czech

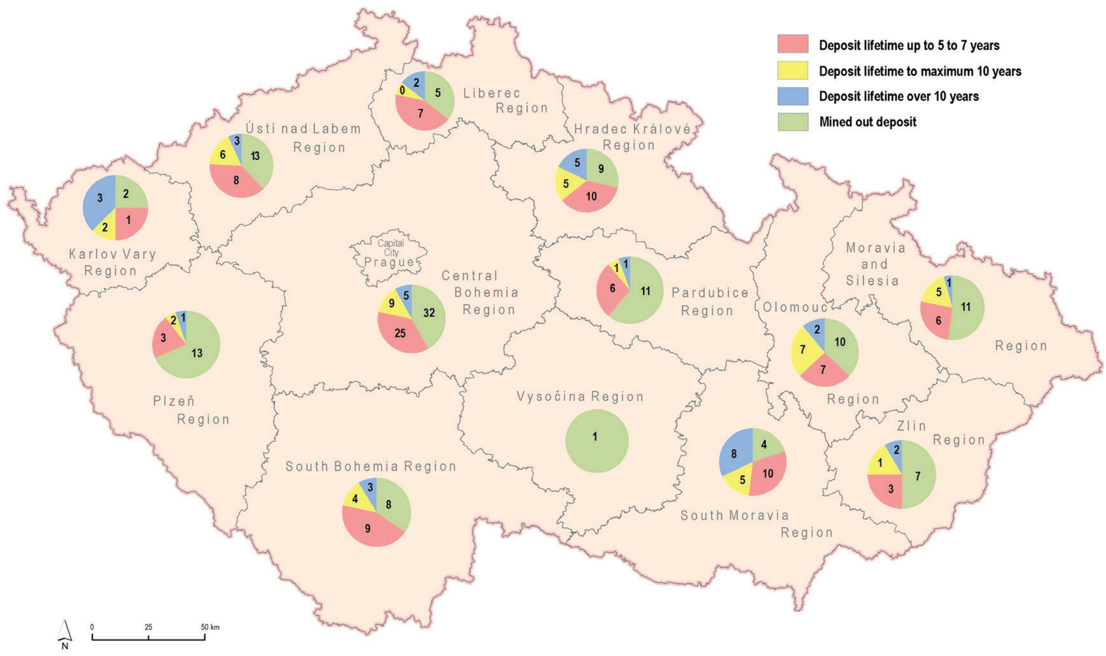
Republic focussing on crushed stone and sand and gravel", which was produced on the basis of the conclusions adopted at the 27th meeting of the Government Council for Energy and Raw Materials Strategy of the Czech Republic on 17 December 2019. The study evaluates the state and perspectives of the use of deposits and resources of selected construction minerals (crushed stone and sand and gravel) in the Czech Republic. It focused on the development of the need and consumption of raw material resources to ensure a sufficient amount of construction raw materials for building transport infrastructure. It clearly evaluated the lifetime of available deposits of extracted construction stone, sand and gravel, both reserved and non-reserved deposits, with particular emphasis on the almost depleted deposits (in time horizons up to 5 years and up to 10 years) and then marginally identified alternative locations and analysed the feasibility of opening them, or eliminating potential conflicts of interest in their use. An integral part of this study is also a brief definition of the fundamental problems in the process of authorizing mining projects for construction minerals and identifying current risk factors that significantly affect authorization processes.

The final conclusions of the study, which was prepared by CGS together with other professional bodies (Mining Union; Mining Design And Consulting Office; GET, s.r.o.; The Association for Road Construction of the Czech Republic and experts for analysing the quality of construction materials), shows that in the short term (i.e. 3 to 10 years) individual mined deposits of construction stone and sand and gravel in the Czech Republic will be affected by the availability of their reserves and therefore at risk of not meeting the economic needs of the state. This issue was also discussed at the last meeting of the Government Council for Energy and Raw Materials Strategy of the Czech Republic in December 2019 including a presentation by the CGS experts and a subsequent debate.

In connection with the gradual use and extraction of existing sand gavel deposits – i.e. for deposits already worked by mining activities (MA) as part of the development, preparation and mining plan (DPMP) and in the panning permit according to the activities carried out by the mining method (ACMM) – a procedure of several years from the project preparation to mining must be considered. Although further expansion or continuation of mining is approached with a reasonable time perspective, until now CGS records sand and gravel extraction projects that have long been solved/prepared for 4 to 8 years with a very unclear result. In any case it is not immediately possible to use other new resources or continue mining on existing deposits until the existing deposits have been completed. Without further extending the existing mining activities or providing the authorization to open a new sand and gravel deposit sufficient production of the assortment of adequate quality covering the demand and the need for sand and gravel in individual regions cannot be guaranteed, especially near already implemented or planned line structures of state or regional importance.

Of the total 204 registered exclusive deposits of sand and gravel only 74 were active in 2021 in the Czech Republic, i.e. with mining authorization (but only 64 of them were active and reported production), and 103 of the total 339 non-reserved mineral deposits had mining authorization (but only 93 were active and reported production). In total there are only 158 active and reporting productionsand pits and their total annual production of sand and gravel was 11.9 mill. m^3 in 2021. In recent years the annual amounts of sand and gravel extraction in the Czech Republic have been very stable – around 6.5 million m^3 (reserved deposits) + about 5 million m^3 (non-reserved deposits). Total aggregate consumption including sand and gravel only in concrete is about 5.5 to 6.7 mill. m^3/year in the Czech Republic. Sandpits containing deposits of non-reserved mineral make up the largest share with low resource life.

Number and service life of mined and mined out sand and gravel deposits in the regions of the Czech Republic



Sand and gravel is the only construction material where non-reserved extraction is not just a supplementary activity but has recently accounted for around 45 to 47% of total production. The Czech Republic has seemingly large amounts of geological reserves of sand and gravel but the amount of reserves that can be mined in deposits of non-reserved mineral are significantly lower (555 mill. m^3 – just over 19% of the total geological reserves) and the reserves with permitted mining according to DPMP are even lower (133 mill. m^3 – slightly more than 6%). This situation is very worrying with regard to ensuring a continuous supply of sand and gravel.

The production and consumption of sand and gravel has been growing significantly over the last 8 years. Prices of extracted construction aggregate prices are also rising significantly (by 15% to 25% per 1 ton on average over the last year), and moreover there is a shortage of the 4/8, 8/16, 16/32mm gross fractions. In the medium and long term, the construction and the construction material industries have sufficient reserves of production capacity, but the real availability of stocks of input raw materials that is being reduced at a high rate can pose a problem.

The requirements for the quality and amount of the produced construction materials are getting significantly stricter, and in most regions of the Czech Republic there is a significant shortage of the 4/8, 8/16, 16/32 mm crude fraction. At the moment, demand for high-quality sand and gravel with rougher granulometry (4/8, 8/16, 16/32mm) has increased as most of the currently operated deposits produce a predominant 0/4 mm sand fraction at the expense of the coarse fraction. Prices per ton of rougher grain grades increased by at least 20 to 30% between 2018 and 2021. Some regions are heavily deficient in the natural resources of the extracted aggregate, e.g. in the Vysočina Region sand and gravel must be transported from the remote South Bohemian and South Moravian regions. A large part of the Karlovy Vary Region, the Pilsen Region, the Moravian-Silesian Region, the Ústí nad Labem Region (with its only source in the district of Litoměřice and partly Louny), the Zlín Region and the whole southern part of the Central Bohemia Region is starting to have a deficiency of sand and gravel (this even faster deploys the available reserves from the districts of Mělník, Nymburk, Kolín, Praha-východ and Mladá Boleslav). Insufficient sand and gravel crude 4-8-16-32 mm fractions are becoming a problem throughout the country, as the sand fraction predominates over the gravel in most sandpits.

Since about 1993, along with the extraction in reserved deposits of construction minerals the importance of extraction in non-reserved deposits carried out on the basis of relevant planning permission has gradually increased. Non-reserved deposits currently produce high annual amounts of high-quality concrete sand and sand and gravel and are starting to have a significant share in the total production of construction minerals in the Czech Republic. Unfortunately, these resources are being gradually exhausted, and new resources for planned use are encountering major issues.

According to the applicable legislation a new reserved deposit of non-reserved mineral can no longer be determined although in many cases these are more important deposits in terms of use and economy than in many reserved deposits. In addition to reserved deposits non-reserved deposits have been playing an economically more important role recently. These perspective deposits, especially of construction minerals, are very difficult to implement in the territorial planning documentation (e.g. in the land development principles) especially when they are unused/ reserved. In the future, it can be assumed that this contradiction will increase due to completing almost depleted reserved deposits and shortages in raw material on the market, as well as progress in the technology of mining and processing mineral resources. After 20 December 1991, i.e. when Act No. 541/1991 Coll., amending and supplementing Act No. 44/1988 Coll., on the Protection and Utilization of Mineral resources (Mining Act) came into force and stipulated that newly defined deposits of non-reserved minerals – building minerals (sand and gravel, crushed stone, stone for rough stone-cutting production, raw minerals for bricks) cannot become reserved deposits and therefore are a part of the land (section 7 of the mining act), the state authorities have withdrawn from any investment in the search for non-reserved minerals.

A major problem in the use of non-reserved mineral deposits includes disproportionate to significantly disadvantaged conditions of payments for the removal of land from the Agricultural Land Fund (ALF), especially deposits of construction minerals, compared to identical activities involving the use of reserved deposits of a non-reserved mineral in the same geological, deposit and environmental conditions. The inadequacy consists mainly in disproportionately higher one-off payments taking into account the environmental weight of effects of various environmental factors (in some cases 10 to 15 times higher). The amount of these payments is currently devastating the vast majority of non-reserved sand and gravel deposits. These are the deposits with extraction from water where neither technology nor the legislation allows their reclamation to arable soil. Moreover, “movable projects” such as warehouses, logistics areas, residential, commercial and storage areas, etc., are located on areas with the most valuable land (protection class I and II). Agricultural land is a valuable resource, but it is taken much more for industrial purposes than for mineral mining.

While the share of recycled products is increasing these are not suitable for standard applications in the linear infrastructure. The required technological characteristics cannot be achieved with these recycled products. Recycled aggregates are typically far worse in quality and their use in the upper and most heavily loaded layers of roads is technologically highly restricted or even excluded. Recycled products can be effectively used as an auxiliary material for multiple constructions, but not as the main material. Increasing the share of recycled materials at construction sites is an important aspect due to the growing focus on the circular economy. However, the amounts of recyclates produced from construction and demolition waste are not sufficient. According to the Association for the Development of Recycling building materials in the Czech Republic the use of recyclates in the construction industry is increasing, but its pace is relatively slow. It follows from the data of the Association that, for example, between 2007 and 2011 the ratio of recyclate production to the production of crushed stone and sand and gravel was around 4%. In 2017–2021 this was already 13.5–17%, an increase of three and a half times. The gradual substitution of primary mineral raw materials by recyclates has certain limits because many applications in the construction sector require high-quality extracted and crushed aggregate from primary sources (e.g. high-strength concrete, railway ballast superstructure, etc.). Following the recycling the aggregate must meet the technical requirements for gradation, small particle content, fine particle content, grain shape, edge rounding, the content of foreign particles as well as the tests for strength, rate of absorption, resistance to freezing, the proportion of shale grains. This is because of the precondition of maintaining the original mechanical-physical properties which should be constant. Due to reuse recycled aggregates lose the required quality parameters. Therefore many construction projects do not even permit the use of recyclates and consistently require the use of primary raw minerals.

Conclusion

Overall, most of the current resources of sand and gravel and crushed aggregate were opened before 1989, in the best case some sand and gravel deposits in the nineties of the last century. Most large gravel resources have a real life span of 7, max. 15 years. This implies that if the process of "recovery" of some substantial deposit of the extracted aggregate is now started, it can be assumed that the actual extraction commences at the earliest in 2027-2035, when many existing deposits will be inactive. Without certain substantial changes in the settings of all steps – including the legislation – that would allow the use of deposits of the extracted aggregate, this "critical" situation will undoubtedly occur. The industrial acquisition of mineral deposits is usually very costly and is associated with a high risk expressed by differences between evaluated assumptions and financial or other economic results and the consequences of their use. The results of the economic and financial evaluation must provide potential investors with evidence of the economic viability of the project, the expected profit level of investment projects that are offered. Unfortunately, the current setting of approval processes in the framework of the valid legislation of the Czech Republic does not allow potential investors to find the necessary degree of certainty and success for the economic return of significant funds put in investment projects over the long term, i.e. geological surveys, opening and exploiting new deposits of natural mineral resources for construction and other purposes. The administrative procedure for obtaining authorization for opening, preparing and exploiting mineral deposits is very complex and lengthy, and replacing the capacities of already depleted or almost depleted mineral deposits with new ones is not taking place at an adequate pace. Therefore, in some localities of the Czech Republic **an imbalance arises between the demand and supply of mainly the raw minerals needed for construction sector**. The factors affecting this situation include, among other things, often hard to solve conflicts of interest between landowners and mining companies, meeting very strict conservation and environmental protection requirements and other partial environmental elements (in particular, protecting the agricultural land resources and groundwater resources), the emergence of generally negative public experience with mineral extraction. Media campaigns, which often publish any inadmissibility of mining under any conditions at a particular location during administrative proceedings without the possibility of confronting and applying compromise solutions, are also contributing to this undesirable situation.

It must be realized that the largest part of the high-quality sand and gravel and sand in the Czech Republic comes from the extraction from water and the deposits of sand and gravel in Olomouc, Zlín, South Bohemia regions are mostly situated in protected areas of natural water accumulation (CHOPAV). Under the same conditions, i.e. in the CHOPAV and in the water resources protection zone (OPVZ) classes I and II, a number of projects for extracting sand and gravel deposits were or are permitted, without significant conflict and threats to the quality and yield of groundwater.

In the medium and long term, the construction and the construction material industries have sufficient reserves of production capacity, but the real availability of reserves that is being reduced at a high pace can pose a problem. Currently resources at construction raw mineral deposits licensed for extraction are getting smaller and smaller. Although there is a large number of resources and amounts of geological reserves of crushed stone and sand and gravel recorded in the Czech Republic, the real reserves in MC and in planning permissions usable for business are very low. In the near future possible gradual outages of available resources of construction minerals can be expected and the end of the operating life of a large part of existing stone quarries and sandpits at the same time. This worrying situation will result in the available reserves in the Czech Republic being depleted in a short horizon (i.e. under 10 years) resulting in the risk of not meeting the economic needs of the state.

From the state's point of view, the most acceptable solution to the problem of securing construction raw materials appears to be the economical extraction of all verified reserves in DP on the existing exclusive deposits of construction raw materials and support for their expansion within protected deposit areas (CHLÚ).

Developments on the European Gas Markets

Jan Hošek, Czech National Bank

In 2021, we saw a strong rise in gas prices, culminating in a turbulent December. To understand the reasons for this, we need to look not only at the fundamental forces of economy such as demand, supply and stock levels, or the global geopolitical situation, but also at the significant changes in the way natural gas has been traded over the past two decades. This following article shows that there are a number of factors that influence the price of natural gas and that the interplay of these factors has led to historic highs in Europe and Asia in late 2021, which were only surpassed with the invasion of Ukraine by Russian troops. Based on market outlooks and related analysis, a rapid decline in natural gas prices cannot be expected in the coming years.

Published in Global Economic Outlook (*Globální ekonomický výhled*) – March 2022
https://www.cnb.cz/cs/o_cnb/cnblog/Vyvoj-na-evropskem-trhu-se-zemnim-plynem/

Introduction

Global natural gas consumption has been growing the fastest of any fossil fuel for some time and strong growth can also be expected in the future. The industrialisation of emerging economies in Asia, the Middle East and Latin America is contributing strongly to demand growth. The rapidly growing production and transportation of Liquefied Natural Gas (LNG) has made natural gas available in countries that are not close to any gas fields. According to the IEA, natural gas accounted for about a quarter (6,300 TWh) of global electricity production in 2020. Gas-fired power plants are replacing less environmentally friendly coal-fired power plants due to their lower greenhouse gas production. However, their main advantage is their flexibility. They can be (unlike coal-fired power plants) quickly brought from standstill to full operation and vice versa, and are therefore ideal as a back-up to compensate not only for seasonal but also short-term fluctuations in production, especially for solar and wind power plants the rated production capacity of which is growing rapidly. Until the storage of electricity from renewable sources is solved on an industrial scale, gas-fired power plants will be the necessary transition link.

Natural gas consumption in Europe will continue to increase. Gas consumption in Europe was declining at the start of the last decade thanks to the rapid growth of electricity generation from renewable sources, but this trend has reversed since 2015 as gas-fired power plants began replacing coal and nuclear plants that were being closed. Given the temporary inclusion of natural gas among clean energy sources, the consumption of natural gas will grow in the medium term in developed countries as well.

However, Europe is increasingly dependent on natural gas imports due to declining domestic production (Chart 1). Natural gas production in Europe has roughly halved since 2010, due to declines in both continental production (Netherlands) and North Sea production (UK). Therefore, consumption is still largely met by imports of pipeline gas from Russia, Norway, North Africa and Azerbaijan and imports of liquefied natural gas (LNG). According to the EIA, the largest share of LNG imports to Europe in 2021 came from the US (26%), Qatar (24%) and Russia (20%). Russia remains the largest supplier of pipeline gas to Europe and it

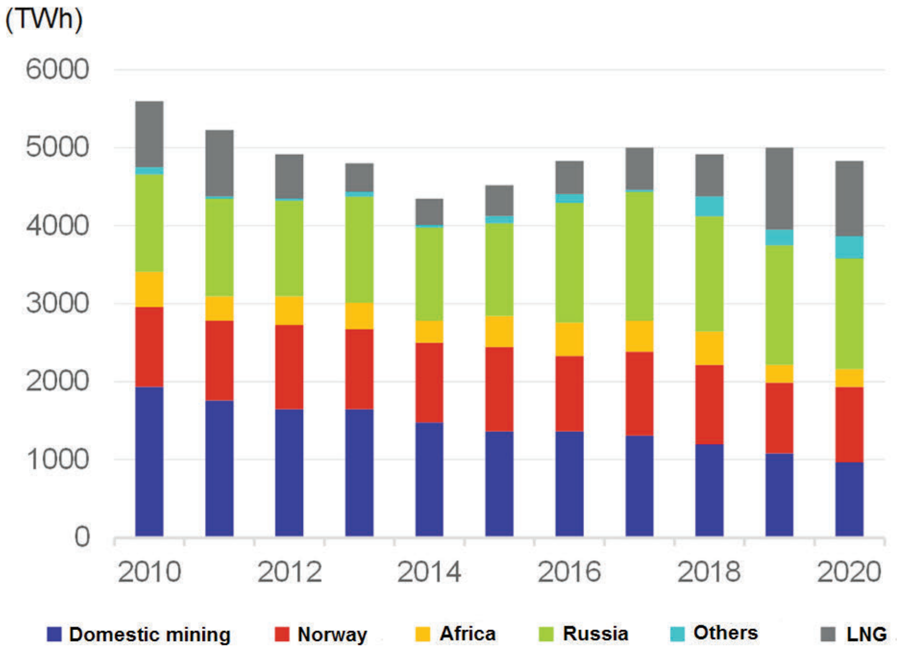


Chart 1 – Structure of natural gas supplies to the European market

Source: EIA, own calculation

Note: 1 TWh is about 95 million m3 of natural gas

prefers to provide supplies on the basis of long-term bilateral contracts. For transport, it mainly uses the new Nordstream pipelines (along the Baltic Sea bed) to Germany and Turkstream (along the Black Sea bed via Turkey) to southern Europe. Gazprom, the monopoly exporter of Russian gas, is limiting supplies through traditional pipelines via Ukraine or Belarus and Poland.

The global gas market is becoming increasingly interconnected thanks to the growing production of LNG. However, the mechanisms by which natural gas is traded still differ from region to region. Therefore, prices in individual regions are no longer independent and we can observe their gradual convergence. But the increasing interconnectedness of these formerly isolated markets also means that demand or supply shocks in one region also impact distant areas, not only in terms of the price of gas itself but also of related commodities (electricity, fertiliser or chemicals). However, despite partial convergence, natural gas prices remain divergent across regions in the long term. While natural gas in the USA is now traded exclusively on a market basis (supply, demand, stock levels), supplies in Asia are predominantly based on bilateral long-term contracts, the prices of which are based on the prices of competing fuels (oil, fuel oil, coal, etc.). In Europe, we can observe a strong pressure to move from long-term contracts linked to oil prices to shorter-term, market-based contracts. This should reduce the pricing power of monopoly suppliers and increase the transparency of trading. These processes are also becoming apparent in Asia. Physical or virtual trading hubs are emerging in Europe and around the world, with unrestricted access for suppliers and buyers of physical gas, companies seeking to hedge against price movements, and investors speculating on future price movements. These changes have a particular impact on gas producers, making it more difficult for them to plan new investments and potentially negatively impacting future gas supply. However, even consumers, who should benefit from lower prices due to increased competition in the market, may be exposed to greater uncertainty and price volatility.

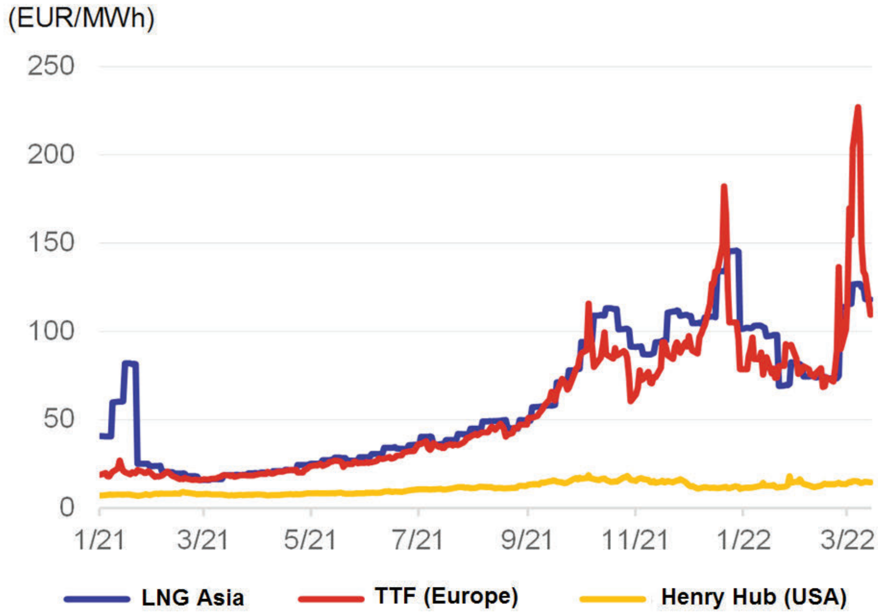


Chart 2 – Development of natural gas market prices from 2021
Source: Datastream, own calculation
Note: TTF = natural gas in Europe; HenryHub = natural gas in the USA

In the past decade, the world gas market has been rather oversupplied due to the rising production of LNG, but the situation changed dramatically in 2021. We covered the developments on the LNG market in detail in September 2018. The conclusions at that time suggested that the excess of LNG production capacity over demand should peak in 2020 and subside in 2022. In retrospect, we can say that up until 2020, the rapid growth in LNG production was indeed putting downwards pressure on gas prices in most regions of the world. However, the global natural gas market was unexpectedly affected by the outbreak of the coronavirus pandemic. This initially reduced demand in 2020 and led to an unprecedented drop in gas prices, but the situation changed fundamentally the following year. With the recovery of the global economy, demand for all primary energy commodities has increased, accompanied by strong price increases. However, the increase in natural gas market prices has been by far the largest, with prices in Europe and Asia reaching historic highs in December 2021, surpassed only after the outbreak of war in Ukraine (Figure 2).

A brief look into the past

International trade in natural gas began to gain importance around the 1960s. The gas was consumed mostly locally near its deposits. Pricing mechanisms included both regulated prices, set by government agencies, and more or less market-determined prices, which were based on the price of another reference (usually competing) commodity, or prices determined purely by the market based on supply and demand on spot markets. The development of these mechanisms and gas prices themselves varied across regions (Chart 3), as there was no way to link these regions commercially (unlike, for example, on the oil market).

As recently as 2010, international gas trade was dominated by long-term contracts indexed to the price of oil. This means that the price of gas was derived from the development of prices of reference (competing) commodities. This mechanism originated in Europe in the 1960s and later spread to LNG trade in Asia. In the United States, on the other hand, trading at trading hubs quickly became dominant, where the price of natural gas was market-driven based on current supply and demand. This form of liberalised market started spreading to Europe in the late 1990s. The first virtual trading hub – the National Balancing Point (NBP) – was established in the United Kingdom. Later, the British pipeline system was connected to Belgium and market trading in natural gas began to take hold in north-west Europe.

Market-based gas trading in Europe did not initially pose a major problem for established market players. A limited number of traditional large trading companies were buying natural gas from a few suppliers (producers) on the basis of long-term contracts (20-year or longer). Gas prices were linked to prices of competing products (oil, petroleum products, coal and other commodities) and price formulas could be adjusted from time to time based on mutual agreement and the market situation. The customer also had some discretion as to the quantity taken in a given year, which typically ranged from 85 to 115% of the nominal annual contract volume. However, the contracts also contained a take-or-pay clause. Thus, the customer had to pay the supplier for a minimum agreed quantity regardless of the actual delivery. Traditional wholesale customers then resold gas under shorter contracts to local distribution networks and large end-users (industrial enterprises). If the price on the spot market developed differently from the prices of long-term contracts, traditional large buyers usually had plenty of room to manoeuvre. If market prices were higher, they took more gas from the supplier and supplied it to the spot market. Otherwise, they reduced their orders in long-term contracts and bought the rest on the spot market. Thus, spot market prices did not deviate much from the indexed prices of long-term contracts.

However, the situation changed fundamentally after the 2008 financial crisis and Europe became a “battleground” for two different price-setting mechanisms (Melling, 2010).

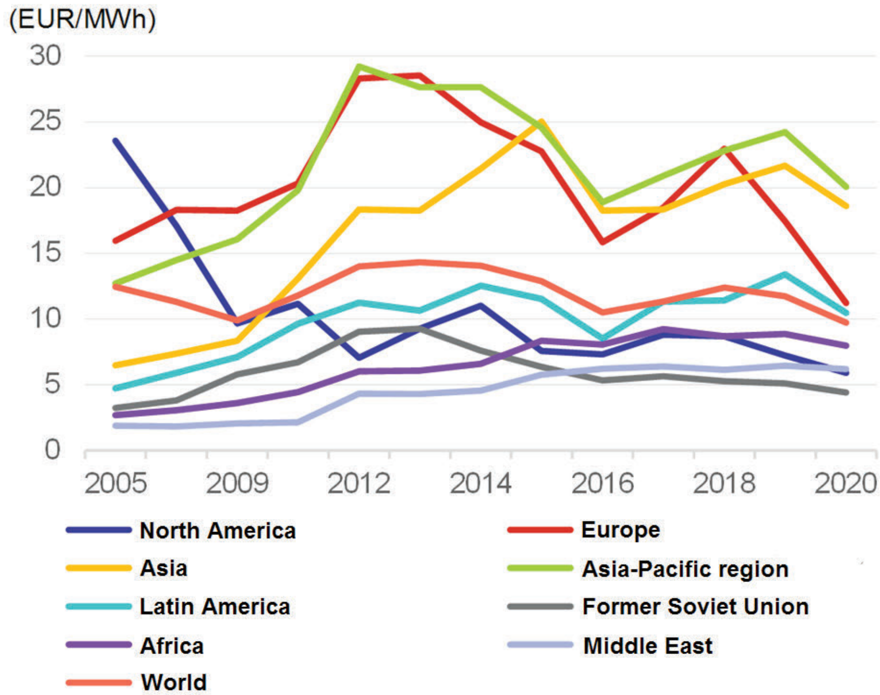


Chart 3 – Development of natural gas prices in individual regions

Source: IGU – Wholesale Gas Price Survey 2021 Edition

Several factors have contributed to this. At the end of 2008, global demand for natural gas, particularly from industrial enterprises, fell sharply. At the same time, the supply of liquefied natural gas on world markets was growing, with supplies being redirected from Asia and the US to Europe. Thanks to the progressive adoption of legislation to ensure greater liberalisation, more and more smaller traders began to appear on the European market, competing with the established wholesale companies. Traditional traders were bound by long-term contracts and take-or-pay clauses, and they were unable to sell the excess purchased gas in the face of such a large drop in demand. Moreover, due to the strong decline in market prices, they were not even able to compete on price. Their only option was to negotiate a modification of the existing contracts, not only in terms of price, but also in terms of minimum purchases.

The share of gas traded at market prices in Europe has started to increase rapidly. Producers (especially from Russia and Algeria), not wanting to walk away from the system of long-term contracts or long-term customers, eventually gave in to their bargaining power. They reduced (albeit temporarily) the quantities required under take-or-pay and started to supply some gas to traditional customers at (lower) market prices, with the quantity gradually increasing. At the same time, however, the amount of gas supplied to spot markets (in particular pipeline gas from Norway and LNG from Qatar) was increasing. The global gas market surplus persisted until 2020, which, together with increasing competition, kept market prices below oil-linked contracts. The share of oil price indexed contracts has thus steadily declined, according to the EIA, from more than 90% in 2006 to less than 10% in 2020 (Chart 4).

Causes of strong natural gas price growth in 2021

After more than a decade-long period of relative surplus on the global gas market, 2021 saw rising gas prices in most regions, culminating in severe turbulence in December. According to the IEA (2022), a number of factors, both on the demand and supply

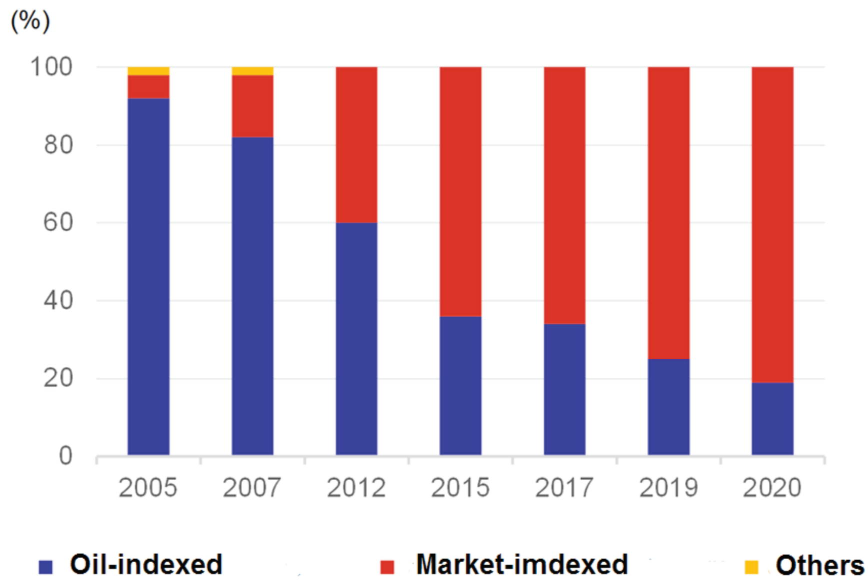


Chart 4 – Growth in the share of gas imported into Europe at market prices

Source: EIA, IGU

side, have contributed to this over time. The 4.6% growth in global natural gas consumption in 2021 was more than double the decline in the previous year.

The strong growth in global demand was driven by both the economic recovery from the previous recession caused by the coronavirus pandemic and a series of adverse weather events. In early 2021, cold weather increased natural gas consumption in Asia. Large importers, such as Japan and South Korea, then replenished stocks during the year after a cold winter. To do this, they made maximum use of their long-term contracts for the import of liquefied natural gas, the oil-indexed price of which was more favourable than the spot market price. Thus, fewer supplies were directed to the spot market (despite rising exports from the US). Demand from China, whose economy has quickly recovered from the pandemic and has been hit by an energy crisis caused by coal shortages and high coal prices, has also been growing strongly. The price of gas on the spot market in Asia skyrocketed. Gas consumption increased as a result of the cold winter and subsequent storage refills in North America. The worst drought in a decade reduced hydropower production during the year in Brazil and Turkey. This was replaced, among other things, by increased use of gas-fired power plants, which supported local demand for natural gas. Demand for natural gas is growing steadily in virtually all emerging countries in Southeast Asia (e.g. India or Pakistan).

Planned and extraordinary LNG extraction and production shortfalls had an adverse effect on the supply side. The coronavirus pandemic caused labour shortages in 2020 and regular maintenance of production facilities in the gas fields was thus postponed. It was then carried out in 2021 at a time of increased gas demand. Furthermore, 2021 also saw a record outage of LNG production due to equipment failures (in some periods up to 8% of nameplate capacity was out of service, according to the IEA).

The situation on the gas market in Europe was quite specific. The gas storage facilities there remained largely empty after a cold and long winter. Low wind production in the summer necessitated a greater involvement of gas-fired back-up power plants in Germany, which, together with increased gas prices and a recovery in industrial activity due to the waning

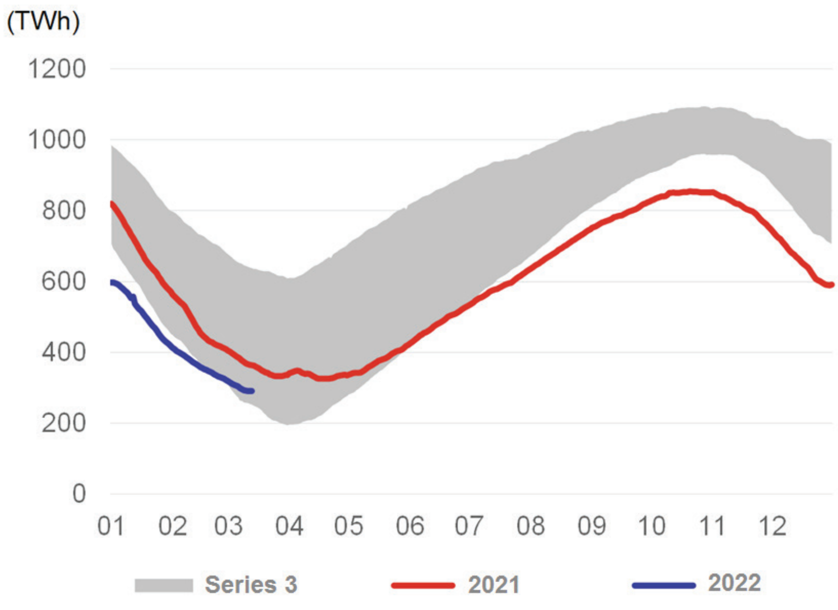


Chart 5 – Development of natural gas storage levels in Europe

Source: Gas Infrastructure Europe - Aggregated Gas Storage Inventory

Note: Minimum and maximum in 2016–2020 for the corresponding day of the year pandemic, slowed the replenishment of reserves during the summer season. The rising price of CO_2 emission allowances also increased the demand for gas. The repletion of gas storage facilities in Europe before the next heating season thus continued to fall below the long-term average during 2021 (Chart 5). The low repletion, coupled with deteriorating political relations with Russia, has led to fears of gas shortages not only during the coming winter but also throughout 2022. This drove natural gas prices to previously unimaginable levels before the Christmas holidays (Chart 2).

Current and expected future developments on the European gas market

Increased LNG supplies to the European market contributed to the relatively calm situation in early 2022. Thanks to the mild winter in Asia during December and sufficient storage levels there, demand has decreased and LNG spot prices in Asia have fallen below European levels. Thus, part of the spot supply (mainly from the US and Qatar) could be redirected from Asia to Europe by the end of 2021. At the same time, China was reselling surplus gas purchased under its long-term contracts. Demand for LNG also declined in Brazil, where heavy rains increased the output of its hydroelectric plants at the expense of gas-fired plants. In January 2022, a record amount of LNG was coming to Europe. While this has only brought the price of gas in Europe back to the levels of October and November (which were still extremely high from a historical perspective), the price volatility was significantly reduced. However, the gas market situation remains tight and the outlook for the period during which gas prices are expected to remain elevated is gradually lengthening.

The weather in Europe was also favourable. Temperatures in January and February were above normal in Europe, and windy weather increased wind production in the North Sea, reducing the need for gas-fired electricity. The European storage deficit relative to the five-year average for the period was thus decreasing.

The IEA expects lower global natural gas demand growth in 2022. This is due to expected weakening economic growth in the world and lower demand in response to high gas prices. On the contrary, supply should recover. This could improve repletion, reduce market tensions and allow natural gas prices to fall.

However, the calming of the natural gas market in Europe did not last long. The invasion of Ukraine by Russian troops and the related sanctions by Western countries on Russia and prospective retaliatory sanctions cast uncertainty on the security of natural gas supplies from Russia. The arrival of a prolonged period of colder weather or outages of renewable electricity sources could also cause complications. The outlook for gas prices is also problematic. Forward market contracts signal that the price of natural gas in Europe should remain at elevated levels for an extended period of time (at least until the first quarter of 2023). In addition, prices do not vary much between summer and winter, so the incentive to replenish European storage during the summer is low. More lasting relief could come in 2025, when more new LNG production and export capacity is expected to be established, particularly in Qatar.

Implications of the liberalisation of the European gas market

Over the past decade, contracts linked to market gas prices have quite clearly established themselves in Europe. There were several reasons. From an administrative point of view, this was an attempt by the EU to liberalise the European gas market through legislation. The surplus of gas on world markets also had a positive effect, reducing the market price of natural gas below the price of oil-indexed contracts. Therefore, customers pushed for gas supplies at market prices. This increased the importance of trading hubs, where more and more contracts were concluded at market prices and their liquidity grew thanks to the massive participation of financial investors.

Purchasing natural gas at market prices has been beneficial to consumers for virtually the entire past decade. Traditional suppliers and wholesale gas buyers gradually lost their pricing power with the long-term gas market surplus and the spot market growth, thus losing part of their stable profits. The advantage of importing natural gas into Europe on the basis of market prices is defended, for example, by Zeniewsky (2021), who acknowledges that liberalisation has exposed European consumers to greater price volatility, but has saved them up to EUR 70 billion over the past decade (Chart 6). Moreover, in the indexed contracts, benchmark oil prices were smoothed using moving averages (6-9 months), so they did not reflect the current market situation. While this allowed for relative stability in gas prices and made it easier for suppliers to plan investments in production and the construction of pipelines or LNG terminals, consumers were not able to benefit from low prices due to the surplus of natural gas on the market at the time (including as a result of the shale gas revolution in the US). In addition, market flexibility is also needed due to the transition to renewable sources of electricity, the output of which is highly variable and requires flexible backup (by gas-fired power plants) and therefore flexible supply of natural gas.

However, 2021 brought a major change. As described above, the global natural gas market saw a strong growth in demand and therefore prices in 2021. The market price of gas has thus reached well above the oil-indexed price. The scenario described by Melling back in 2010 has come true. He predicted that the move to market prices would hurt the traditional large traders

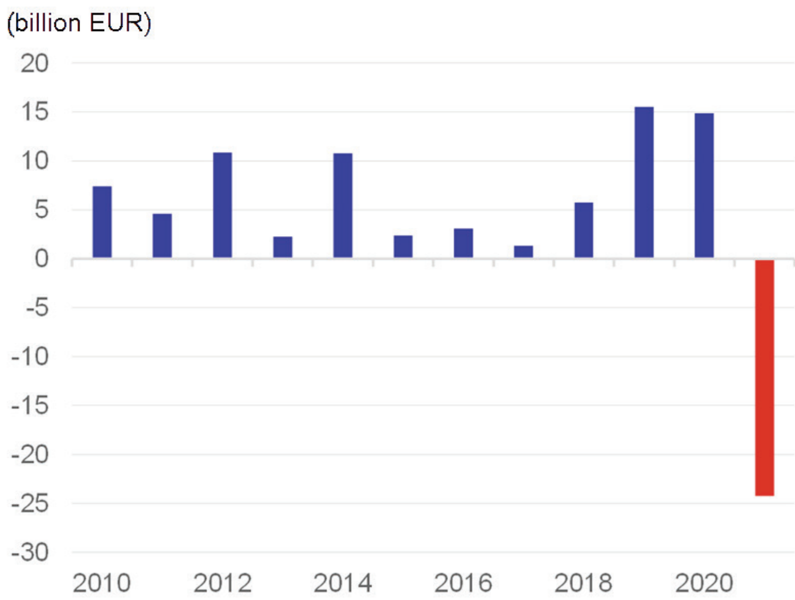


Chart 6 – Comparison of the cost of importing gas into Europe

Source: IEA

Note: Hypothetical difference between the cost of gas imports in the case of 100% oil-indexed prices and the cost based on current import prices.

in the market the most. With the bulk of production in the hands of a few large producers, Europe will almost certainly face oligopolistic behaviour that will allow producers to control gas prices in the longer term. The producers will manage their production to maximise profits. In doing so, they will bypass the traditional wholesalers and also contract with smaller trading companies and large end-users, giving them a better overview of the market situation. If there is then stronger demand growth (which can almost certainly be counted on thanks to the industrialisation of the major emerging economies), the suppliers will again have a great deal of pricing power, which may give them higher profits than the original oil-indexed contracts. European legislation has limited the rather monopolistic behaviour of traditional wholesalers, who have been facing strong competition from smaller trading companies. However, the behaviour of producers is much harder to influence administratively. If it happens that other competitors are unable to increase production sufficiently, even one large producer can influence the market price of gas by limiting its supply to a given market. This was not possible at the time of oil-indexed contracts.

It remains to be seen how viable the move towards a purely liberalised gas market in Europe will be. If strong demand growth and limited production (supply) growth continue in the global gas market, it is possible that the situation in 2021, which was highly disadvantageous for European consumers, will continue in the years to come. This would logically change the opinions on market trading in natural gas. The outcome is also likely to have an impact on the development of trading mechanisms on the Asian LNG market, where the transition to market-based contracts has been slower so far. Trading natural gas on the basis of short-term contracts and market prices introduces more volatility and uncertainty, and thus generally reduces producers' incentives to invest in production, which is financially very demanding and requires a long repayment horizon. Furthermore, the public opinion, influenced by efforts to reduce CO_2 emissions, is generally not in favour of investment in fossil fuel extraction. Banks and investors thus prefer investment projects that focus more on the construction of renewable energy sources.

The actual impact of high gas prices on the economy

Spot prices at trading hubs may not be an ideal measure of the impact of gas prices on the economy. We can observe a large variety of prices on the spot markets. The largest volumes there are trades for the following day and the following month. As on the oil market, the futures price curve can have different slopes. If traders perceive a current surplus of a commodity on the market, the futures curve has a positive slope (contango), which means that prices of contracts with a closer delivery are lower than contracts further away in time. This situation was rather common during the last decade and it was advantageous for traders to buy contracts with shorter delivery. The opposite condition is called backwardation (negative slope of the futures curve). Therefore, the actual average price of imported gas depends on the time structure of the physical contracts concluded and it is difficult to derive such price from spot market prices (where most contracts do not end in physical delivery). However, we can get some idea from customs import statistics. The German Border Price, which is an estimate of the import price of Russian gas, was often (especially in the past) used as an indicator. It was calculated as the ratio of the total price to the physical quantity (in units of energy contained) of gas imported in a given month. Similarly, we can calculate the price of imported gas to the Czech Republic. The results are summarised in Chart 7. It is apparent that a sharp increase

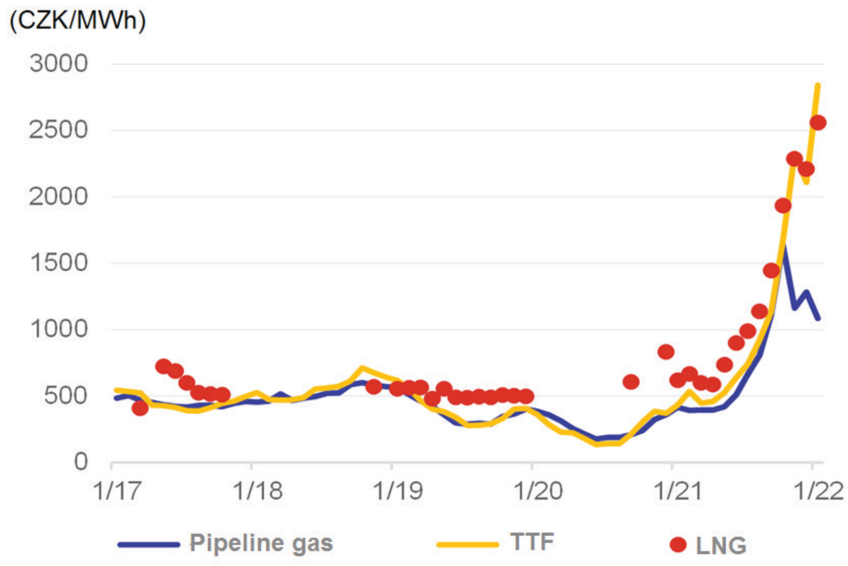


Chart 7 – Comparison of import prices of natural gas into the Czech Republic with the market price on TTF

Source: Datastream, CZSO, own calculation

Note: TTF – average price of a monthly contract for a given month

in market prices in late 2021 may not have a corresponding impact on producer prices or consumer inflation, as some gas has already been contracted earlier. However, the longer the high spot prices persist, the stronger the effect on current import prices, and thus to the economy, can be expected.

Conclusion

The global natural gas market is currently the fastest growing segment of the commodity markets. Natural gas consumption is increasing dynamically, especially in the emerging economies of Asia and South America. The growth in production and export of liquefied natural gas has made the natural gas market more global. Thus, gas prices in one region can now be influenced by developments in remote areas of the world. Global demand for natural gas is growing due to efforts to move away from coal burning, as burning natural gas produces fewer greenhouse gases. In some places, decommissioned nuclear power plants are being replaced by gas-fired plants. Due to the increasing share of renewable energy sources in electricity production, natural gas and gas-fired power plants have become more important as a backup source to these unstable and weather-dependent technologies, and unfortunately, the storage of large volumes of electricity is not yet possible with the current technology. Gas prices are now closely linked to electricity prices (especially in Europe).

The European natural gas market has undergone significant changes over the past decade. The original long-term contracts with gas prices derived from oil and other energy commodity prices were based on the idea of fuel competition at the end customer. They were advantageous for the producers as they provided them with a regular income and allowed them to plan accordingly. This ensured relatively stable prices for consumers. However, they did not take into account the development of fundamental market forces directly on the gas market. The global market for natural gas has been in surplus over the past decade, with low market prices below those indexed to oil. Therefore, consumers have pressed for market prices to be reflected in their contracts and the EU has sought to increase competition on the gas market through legislation. Thus, by 2020, more than 90% of natural gas has already been delivered to the European market on the basis of contracts with a significantly shorter duration and prices determined purely by market forces.

Trading on the basis of market gas prices can result in higher price volatility as well as higher price levels in the long term, especially if there is a shortage of the commodity on the market. This became evident in 2021. Melling (2010) already described the possible consequences of future market liberalisation and the transition to market-based gas pricing. He predicted that the traditional wholesale customers would be the most affected, losing their monopoly-based profits. On the other hand, gas producers are able to adapt to the new situation over time and possibly increase their profits. On the supplier side, there are typically only a small number of large production companies and oligopolistic behaviour cannot be ruled out (and can hardly be administratively regulated). Even one large producer can cause a strong increase in market prices by reducing supply without a major risk of losing market share, as we are seeing today. One of the few tools that the European administration has at its disposal to combat gas price volatility is better use and interconnection of European underground storage facilities, which is currently under discussion. However, only the future will show whether gas trading on a purely market basis will be viable and whether it will take off in other regions outside Europe.

Sources

Birol, Fatih (2022): Europe and the world need to draw the right lessons from today’s natural gas crisis, IEA commentary, 13 January 2022 https://www.iea.org/commentaries/europe-and-the-world-need-to-draw-the-right-lessons-from-today-s-natural-gas-crisis

Heather, Patrick (2012): Continental European Gas Hubs: Are they fit for purpose?, The Oxford Institute for Energy Studies, OIES paper NG63, June 2012 https://www.oxfordenergy.org/wpcms/wp-content/uploads/2012/06/NG-63.pdf

Heather, Patrick (2015): The evolution of European traded gas hubs, The Oxford Institute for Energy Studies, OIES paper NG104, December 2015 https://www.oxfordenergy.org/wpcms/wp-content/uploads/2015/12/NG-104.pdf

Heather, Patrick and Beatrice Petrovich (2017): European traded gas hubs: an updated analysis, The Oxford Institute for Energy Studies, OIES energy insight 13, May 2017 https://www.oxfordenergy.org/wpcms/wp-content/uploads/2017/05/European-traded-gas-hubs-an-updated-analysis-on-liquidity-maturity-and-barriers-to-market-integration-OIES-Energy-Insight.pdf

IEA (2022): Gas Market Report, Q1 2022, January 2022 https://www.iea.org/reports/gas-market-report-q1-2022

IGU (2021): Global Wholesale Gas Price Survey 2021 Edition, International Gas Union, June 2021 https://www.igu.org/resources/global-wholesale-gas-price-survey-2021/

Melling, Anthony J. (2010): Natural gas pricing and its future, Carnegie Endowment for International Peace https://carnegieendowment.org/files/gas_pricing_europe.pdf

Zeniewsky, Peter (2021): Despite short-term pain, the EU’s liberalised gas markets have brought long-term financial gains, IEA commentary, 22 October 2021 https://www.iea.org/commentaries/despite-short-term-pain-the-eu-s-liberalised-gas-markets-have-brought-long-term-financial-gains

Outline of domestic mine production

		2017	2018	2019	2020	2021
Energy minerals						
Uranium	t U	59	34	33	29	27
	Concentrate production, t U (1)	56	29	36	28	26
Bituminous coal	kt	4,870	4,110	3,150	1,861	2,008
Brown coal	kt (2)	39,310	39,187	37,465	29,505	29,278
Crude oil	kt	107	109	81	91	83
Natural gas	mill m^3	171	179	146	138	153
Industrial minerals						
Pyrope bearing rock	kt	34	13	12	1	0
Moldavite (tectite) bearing rock	ths m^3	54	61	42	46	49
	kt (1 m^3 = 1.8 kt)	97	110	76	83	88
Kaolin	Raw, kt (3)	3,669	3,622	3,446	3,069	3,454
	Beneficiated, kt	676	653	629	626	645
Clays	kt	537	469	441	454	456
Bentonite (4)	kt	254	277	357	226	198
Diatomite	kt	34	31	43	46	18
Feldspar	kt	368	449	460	419	504
Feldspar substitutes	kt	34	31	33	29	24
Silica minerals	kt	17	16	17	11	20
Glass sand	kt	755	743	740	683	715
Foundry sand	kt	556	559	514	470	583
Limestones and corrective additives for cement production	kt	10,787	11,727	11,806	11,296	11,480
Dolomite	kt	450	451	453	398	393
Gypsum	kt	7	8	10	17	17
Construction minerals						
Dimension stone	Mine production in reserved deposits, ths m^3 (5)	111	116	117	135	125
	Mine production in reserved deposits, kt (1 m^3 = 2.7 kt) (5)	300	313	315	365	338
	Mine production in non-reserved deposits, ths m^3 (6)	33	18	16	47	62
	Mine production in non-reserved deposits, kt (1 m^3 = 2.7 kt) (6)	89	49	42	127	167
Crushed stone	Mine production in reserved deposits, ths m^3 (5)	12,776	14,140	14,057	14,247	14,883
	Mine production in reserved deposits, kt (1 m^3 = 2.7 kt) (5)	34,495	38,178	37,954	38,467	40,184
	Mine production in non-reserved deposits, ths m^3 (6)	1,251	1,151	1,449	1,465	1,703
	Mine production in non-reserved deposits, kt (1 m^3 = 2.7 kt) (6)	3,378	3,108	3,912	3,956	4,598
Sand and gravel	Mine production in reserved deposits, ths m^3 (5)	6,198	6,499	6,204	6,476	6,602
	Mine production in reserved deposits, kt (1 m^3 = 1.8 kt) (5)	11,156	11,698	11,167	11,657	11,884
	Mine production in non-reserved deposits, ths m^3 (6)	4,829	4,875	4,897	4,821	5,270
	Mine production in non-reserved deposits, kt (1 m^3 = 1.8 kt) (6)	8,692	8,775	8,815	8,678	9,486
Brick clays and related minerals	Mine production in reserved deposits, ths m^3 (5)	678	825	694	560	595
	Mine production in reserved deposits, kt (1 m^3 = 1.8 kt) (5)	1,220	1,485	1,249	1,008	1,071
	Mine production in non-reserved deposits, ths m^3 (6)	251	298	301	404	411
	Mine production in non-reserved deposits, kt (1 m^3 = 1.8 kt) (6)	452	536	542	727	740
Metallic ores (not mined)						

(1) corresponds to sales production (without beneficiation losses)
(2) Czech Statistical Office presents so-called sales mining production which is production of marketable brown coal and reaches on average about 95 % of given mine production
(3) raw kaolin, total production of all technological grades
(4) including mining of montmorillonite clays overburden of kaolins since 2004
(5) decrease of mineral reserves by mining production
(6) estimate

Domestic share in the world mine production

			2017	2018	2019	2020	2021
Energy minerals							
Uranium (U)		world: WNA	0.10%	0.06%	0.07%	0.06%	0.05%
Bituminous coal		world: IEA, BP	0.07%	0.07%	0.04%	0.03%	0.03%
Brown coal + Lignite		world: IEA, BP	4.73%	4.68%	5.07%	4.62%	4.60%
Crude oil		world: BP	0.002%	0.002%	0.002%	0.002%	0.002%
Natural gas		world: BP	0.004%	0.005%	0.004%	0.004%	0.004%
Industrial minerals							
Gemstones	Pyrope bearing rock		N	N	N	N	N
	Moldavite (tecti-te) bearing rock		N	N	N	N	N
Kaolin		world: MCS	9.92%	9.79%	8.20%	6.98%	7.04%
Clays			N	N	N	N	N
Bentonite		world: MCS	1.34%	1.32%	1.93%	1.41%	1.27%
Diatomite		world: MCS	1.13%	1.15%	1.48%	2.09%	0.78%
Feldspar		world: MCS	1.56%	1.95%	1.77%	1.82%	1.90%
Feldspar substitutes			N	N	N	N	N
Glass + Foundry sand		world: MCS	0.62%	0.43%	0.38%	0.44%	0.54%
Limestones		world: MCS *	0.22%	0.24%	0.23%	0.22%	0.26%
Dolomite			N	N	N	N	N
Gypsum		world: MCS	0.003%	0.004%	0.007%	0.01%	0,01%
Construction minerals							
			N	N	N	N	N
Metallic ores (not mined)							

** calculation based on lime and cement production. 2 t of limestone = 1 t of lime or 2 t of cement*

ENVIRONMENT AND MINERALS

Mining and nature protection

1,519 reserved and 810 non-reserved mineral deposits were registered in the Czech Republic as of December 31. 2021. The number of exploited deposits was markedly lower – 487 reserved and 179 non-reserved. Only 36 reserved and 8 non-reserved deposits were mined in the specially nature protected areas, which represents 7.47 % and 4.40 % of the total number, respectively.

Act No 114/1992 Coll., on nature and landscape protection in its present wording regulates activities in specially protected areas (ZCHÚ) of the Czech Republic (national parks – NP (Národní park), protected landscape areas – CHKO (Chráněná krajinná oblast), national nature reserves, nature reserves, national nature monuments and nature monuments). According to this Act, all mineral mining (section 16) in national parks (with exception of crushed stone and sand mining for construction in the territory of the national park), in the first zone of protected landscape areas (section 26) and in national nature reserves (section 29) is prohibited. Although the mining of mineral resources is not prohibited by law in other areas (2nd to 4th zones of the CHKO, nature reserves, national nature monuments and nature monuments), it is very difficult to obtain authorization. Legal regulations which mention prohibition of the "permanent damage

Specially protected areas (ZCHÚ) in the Czech Republic

Number/year	2017	2018	2019	2020	2021
Total number	2,630	2,639	2,663	2,694	2,698
National parks (NP)	4	4	4	4	4
Protected landscape areas (CHKO)	26	26	26	26	26
Others	2,600	2,609	2,633	2,664	2,668

Source: AOPK ČR (2020)

National parks in the Czech Republic

National park	Year of the NP declaration	National park area (km^2)	Proportion on the territory of the Czech Republic 78 864 km^2 (%)
Krkonoše Mountains National Park	1963	363	0.46 %
Podyjí National Park	1991	63	0.08 %
Šumava National Park	1991	685	0.87 %
National Park Bohemian Switzerland	2000	79	0.10 %

Source: AOPK ČR (2020)

Structure of ZCHÚ in 2021

Category of specially protected areas	Number	Area (km^2)	Proportion on the territory of the Czech Republic 78 864 km^2 (%)
LARGE-EXTENT ZCHÚ			
National parks (NP) – mining explicitly prohibited	4	1 191	1.51
Protected landscape areas (CHKO)	26	11 375	14.42
– (in them the 1st zones of CHKO where mining is explicitly prohibited)	26	920	1.17
ZCHÚ with mining explicitly prohibited by the Act No. 114/1992 Sb.	29*	2 066*	2.62*
SMALL-EXTENT ZCHÚ			
National nature monuments (NPP)	128	82.7	0.11
National nature reserve (NPR)	116	304.4	0.39
Nature monuments (PP)	1,591	336.5	0.43
Nature reserves (PR)	833	435.0	0.55
NPP, NPR, PP, PR	2,668	1,158.6	1.47
– (from them NPP, NPR, PP, PR on the area of NP, CHKO)	753	472	0.59
LARGE-EXTENT AND SMALL-EXTENT ZCHÚ – total	**2,698**	**13,731**	**17.41**

** data from 2013, currently without updating*
Source: AOPK ČR (2022)

of the soil surface" are the main reason – and they practically exclude mineral mining. A further reason is the civil activity in the field of environmental protection.

Mineral deposits are mined, and were in the past mined, in the CHKO in majority of cases where the mining claims were already determined before these CHKO were established. Mining in the CHKO declined after 1989 till 2002, after it rather grows till 2008 and after declines and stagnates respectively namely of registered deposits, which follows from the data in the table "Mining of reserved and non-reserved mineral deposits in CHKO" below and also from the fact that reserved deposits were mined in 19 from 25 CHKO in 2007 and 2008 (see the table "Mining of reserved and non-reserved mineral deposits in individual CHKO") compared to 17 from 25 CHKO in 2006. Deposits were mined only in 16 CHKO in 2009 and 2010, in 14 CHKO in 2011 till 2014 and in 15 CHKO in 2015 when CHKO Kokořínsko was extended about 140 km^2 and now is colled Kokořínsko-Máchův kraj. In 2016, the number of protected landscape areas in the Czech Republic increased to 26 (CHKO Brdy was established on 1. 1. 2016, raw materials mined in 17 CHKO). The CHKO mined raw materials number is 17 in 2021.

As far as the impact of mining on the area is concerned. the CHKO Český kras (Bohemian Karst – limestone mining) is especially unfavourably affected. The impact on some other

Mining of reserved and non-reserved mineral deposits in CHKO, kt

Mineral	Reserved deposits					Non-reserved deposits				
	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
Gemstones*	34	13	8	1	0	0	0	0	0	0
Crude oil	0	0	0	0	0	0	0	0	0	0
Natural gas**	2	1	1	1	1	0	0	0	0	0
Quartz sand***	255	195	547	494	607	0	0	0	0	0
Feldspar	315	363	360	352	432	0	0	0	0	0
Limestone	3,284	3,183	3,228	3,040	5,043	0	2	0	0	0
Dimension stone**	77	55	48	85	95	1	1.4	1	0.1	0
Crushed stone**	2,945	3,996	4,454	4,340	4,153	19	301	30	21	22
Sand and gravel**	1,595	1,087	1,474	1,333	1,426	5	13	20	18	0
Brick clay**	0	0	0	0		0	0	0	0	0
Total	**8,506**	**8,758**	**9,865**	**9,647**	**11,757**	**25**	**305**	**51**	**39**	**22**
Index, 1990 = 100	53	54	62	61	74	–	–	–	–	–
Index, 2000 = 100	92	95	109	108	131	12	99	17	13	7

* *pyrope bearing rocks,*

** *conversion to kt: natural gas (1,000,000 m^3 = 1 kt), dimension and crushed stone (1,000 m^3 = 2.7 kt), sand and gravel and brick clays (1,000 m^3 = 1.8 kt),*

*** *The increase in the extraction of the quartz sand non-reserved deposits in 2016 is due to an increase in the mining share of Srní Okřešice locality*

CHKO, especially CHKO Třeboň region. Poodří. České středohoří Mts. Blanský les is still rather high (see Tab. “Impact of mining of reserved deposits in CHKO”). The reduction in mining by 32% occurred in 2017 in the České středohoří protected landscape area. The mining activities in the area of Moravský kras (Moravian Karst) were terminated in 2014 by abandoning of mining limestone deposit Ochoz-Skalka. In 2017 two deposits are being mined here again – the limestone deposit Ochoz u Brna and the deposit of foundry sands Rudice-Seč. In 2018 were not operated the deposits in the area of Moravský kras again – neither Ochoz u Brna nor Rudice-Seč. In 2019 was the other limestones deposit Ochoz u Brna in operation again. From 2015 when CHKO Kokořínsko was extended about 140 km^2 (now is called Kokořínsko-Máchův kraj) is reported quartz sand deposit Srní – Okřešice in this CHKO. In 2016 the Brdy protected landscape area (CHKO) was established but mining there was not take place. In 2017, however, a crushed stone in the total amount of 11 kt was already mined on two localities (Záběhlá-Červený lom and Chaloupky-hlína) and this situation was the same in 2018. However, in 2019 and 2020, mining at the site did not take place.

It is possible to get a clearer picture of mining activities in the Czech Republic from following map.

As well as the Act No. 114/1992 Coll., on nature and landscape protection. Act No. 100/2001 Coll. on environmental impact assessment and the Decree of the MŽP No. 17/2011 Coll.

Mining of reserved and non-reserved mineral deposits in individual CHKO, kt

Name of CHKO	2017	2018	2019	2020	2021
Beskydy Mts.	35	24	18	43	52
Bílé Karpaty Mts.	222	192	177	197	242
Blaník	0	0	0	0	0
Blanský les	725	718	1,024	806	1,023
Brdy **	11	7	0	0	0
Broumov region	144	108	79	153	139
České středohoří Mts.	1,657	2,300	2,122	2,053	2,025
Český kras (Bohemian Karst)	3,344	3,222	3,293	3,369	3,224
Český les Mts.	0	0	0	0	0
Český ráj	0	0	0	0	0
Jeseníky Mts.	97	130	74	68	23
Jizerské hory Mts.	22	12	0	0	0
Kokořín region – Máchův kraj	253	195	547	494	388
Křivoklát region	298	297	346	301	397
Labské pískovce (Elbe sandstones)	0	0	0	0	0
Litovelské Pomoraví region	0	0	0	0	0
Lužické hory Mts.	0	0	5	0.1	0
Moravský kras (Moravian Karst)	1,269	1,857	1,997	1,822	1,933
Orlické hory Mts.	0	0	0	0	0
Pálava region	0	0	0	0	0
Poodří region	136	196	116	200	191
Slavkovský les region	218	255	279	267	302
Šumava Mts.	86	120	170	76	66
Třeboň region	1,555	1,235	1,186	1,165	1,365
Žďárské vrchy Mts.	174	132	165	141	157
Železné hory Mts.	144	30	174	203	161
Total mine production (rounded)	**10,390**	**11,030**	**11,772**	**11,359**	**11,688**

* *in 2014 the CHKO Kokořínsko was extended about 140 km^2, now is called Kokořínsko-Máchův kraj*
** *CHKO Brdy was established on 1. 1. 2016*

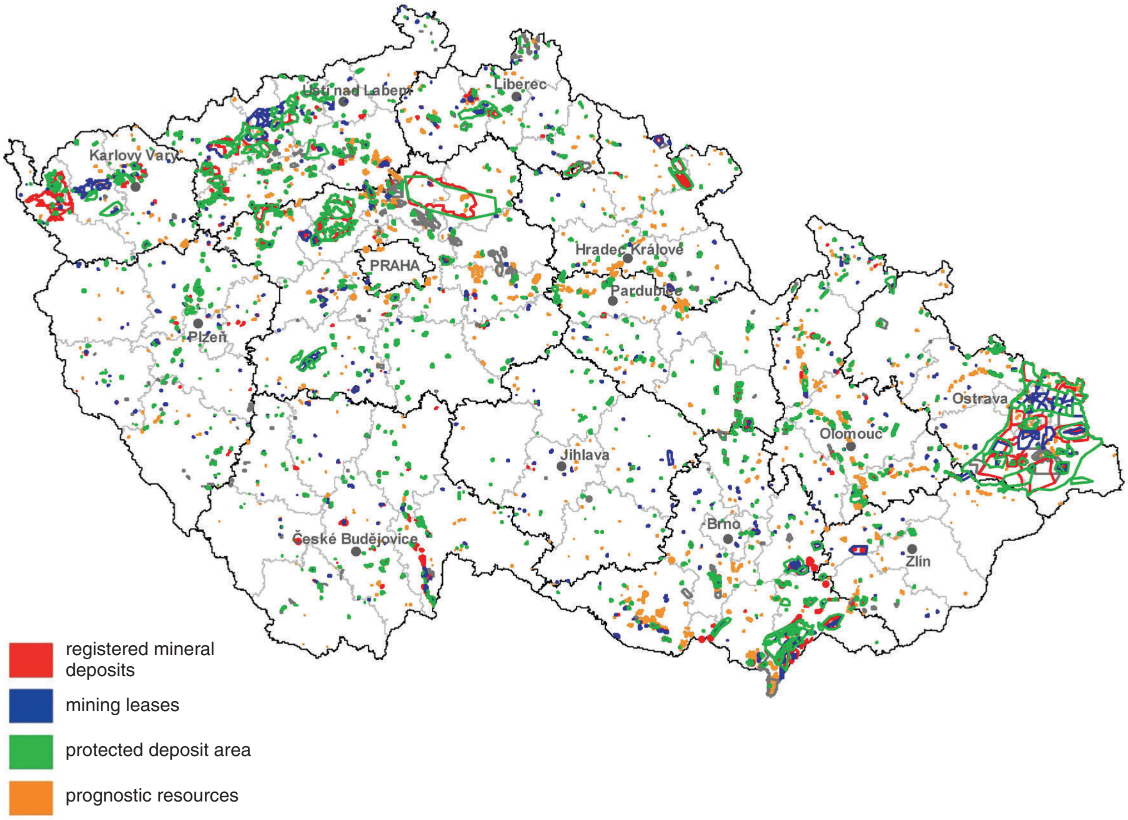
(formerly No. 395/1992 Coll.), by which some provisions of the Act No. 114/1992 Coll. are applied, have a fundamental influence on permission for exploration and mining.

The Mining Act No. 44/1988 Sb. obliges the mining companies by its section 31 to reclaim the areas with mining impacts and to create financial means for this reclamation. These are considered as mining costs from the viewpoint of the profi tax. Table “Development of reclamations after mining” shows that the areas with mining impact decreased and those reclaimed increased in 2016–2020.

Impact of mining of reserved deposits in CHKO, t/km² in a year
(areas of CHKO as of December 31)

Name of CHKO	area km² in 2021	2017	2018	2019	2020	2021
Beskydy Mts.	1,205	29	20	15	35	43
Bílé Karpaty Mts.	747	298	261	240	264	324
Blaník	40	0	0	0	0	0
Blanský les	220	3,311	3,279	4,655	3,663	4,650
Brdy*	345	32	20	0	23	0
Broumov region	432	334	250	183	404	322
České středohoří Mts.	1,069	334	250	183	404	322
Český kras (Bohemian Karst)	132	1,549	2,152	1,985	1,921	1,894
Český les Mts.	466	25,333	24,409	24,947	25,523	24,424
Český ráj	182	0	0	0	0	0
Jeseníky Mts.	743	131	175	100	91	31
Jizerské hory Mts.	374	59	32	0	0	0
Kokořín region – Máchův kraj*	410	617	476	1,334	1,205	946
Křivoklát region	625	477	475	554	482	635
Labské pískovce (Elbe sandstones)	243	0	0	0	0	0
Litovelské Pomoraví	93	0	0	0	0	0
Lužické hory Mts.	271	0	0	20	0,5	0
Moravský kras (Moravian Karst)	97	13,082	19,144	20,588	18,784	19,928
Orlické hory Mts.	233	0	0	0	0	0
Pálava region	85	0	0	0	0	0
Poodří region	82	1,659	2,390	1,415	2,439	2,329
Slavkovský les	611	357	418	457	437	494
Šumava Mts. (CHKO + NP)	1,680	51	71	101	45	39
Třeboň region	687	2,263	1,798	1,726	1,695	1,987
Žďárské vrchy Mts.	709	246	186	233	197	221
Železné hory Mts.	285	505	105	611	801	565
TOTAL (total mining/total area)	**12,065**	**861**	**914**	**976**	**942**	**969**

Note: an impact exceeding 10,000 t/km² in a year is regarded as critical
** CHKO Brdy was established on 1. 1. 2016*
*** in 2014 the CHKO Kokořín region was extended about 140 km², now is called Kokořín region-Mácha's country (Máchův kraj)*



Mining activities charge of the Czech Republic territory

Methods of reclamation used in 2020 are shown in the table “Reclamation after mining of reserved minerals in 2020”.

Mining influences the environment. changes the character of the landscape, and alters ecological conditions for flora and fauna. In some areas mining activities can last several human generations. This way the impact of mining persists and a more permanent new arrangement of natural conditions and relationships in its area is not quickly evident. The new arrangement can be equal to or even better than the original one, of course on a different level. Examples include artificial lakes formed e.g. in south Bohemia by sand and gravel mining, constructions and sport grounds in former quarries or specially protected nature areas proclaimed paradoxically in the territory of former quarries, and also 35 hectares of new vineyards planted as agricultural reclamation of a closed brown coal mine in the north of Bohemia in the Most wine region. They represent by their area almost 6.5 % of the total 550 hectares of productive vineyards of the Czech wine region.

In Bavaria, Germany, they studied the plant biodiversity in local quarries (S.Gilcher-U. Tränkle (2005): Steinbrüche und Gruben Bayerns und ihre Bedeutung für den Arten- und Biotopschutz.-Bayerischen Industrieverband Steine und Erden e.V., München). Of the 2 533 known plant species (of which 701 are endangered) in Bavaria in quarries whose combined area amounts to 0.006 % of Bavaria´s total area, they counted 1,039 species (41 % of the total count), of which 87 species were endangered (12.4 % of all endangered plant species).

In Baden-Württemberg. Germany. (Schelkingen quarries – raw material for cement) an original research project was developed *(Brodkom E.-Benett P.-Jans D. (editors)(2001): Good environmental practice in the European extractive industry. A reference guide – Environnement.*

Area affected by mining by region, 2021

Region	Area affected by mining in mining leases (km²)	Area affected by mining outside mining leases (km²)
Capital City of Prague	1.21	0.02
Central Bohemia	19.45	0.82
South Bohemia	10.63	0.78
Plzeň	87.73	0.87
Karlovy Vary	46.35	27.78
Ústí nad Labem	128.85	11.41
Liberecj	14.74	4.69
Hradec Králové	3.72	0.17
Pardubice	6.77	0.63
Vysočina	4.54	1.59
South Moravia	18.73	1.10
Olomouc	12.73	2.27
Zlín	7.85	0.15
Moravia and Silesia	90.26	0.83
Czech Republic	**374.63**	**53.11**

Development of reclamations after mining

km²		2017	2018	2019	2020	2021
Reserved deposits	Area with manifestation of mining, not yet reclaimed	459	493	426	414	336
	Reclamations in process	70	63	60	63	28
	Reclamations finished since the start of mining	245	252	255	271	273
	Reclamations finished in the given year	5	5	4	12	2.4
Non-reserved deposits	Area with manifestation of mining, not yet reclaimed	16	15	16	17	10.3
	Reclamations in process	4	4	5	4	2.3
	Reclamations finished since the start of mining	4	3	3	4	4.4
	Reclamations finished in the given year	0.8	0.3	0.2	0.9	0.3

hors-série no 1. p. 35, Société de l'industrie minérale, Paris.). "This consisted of using cut grass to encourage vegetation growth by spreading it over the floor of a closed-down quarry. In order to protect germination. the grass counteracts high soil temperatures. The moisture of the soil is retained much longer. and the air humidity under the grass is higher. ... Corresponding tests on the following substrates were carried out at the quarry: raw soil substrate (unchanged quarry site). mixed substrate (screen residue and excavated material). excavated material. ... With regard to effectiveness. it can be stated that 50 to 60% of the species established on the areas from which the cut grass was taken were introduced and naturalised in an single mowing

Reclamation after mining of reserved minerals in 2020*

Region	Reclamations in process								Reclamations finished							
	agricultural		forest		water		other		agricultural		forest		water		other	
	in DP	out DP	in DP	out DP	in DP	out DP	in DP	out DP	in DP	out DP	in DP	out DP	in DP	out DP	in DP	out DP
South Bohemia	8	0	49	5	10	0	10	0	57	69	88	30	306	3	42	1
South Moravia	165	3	38	0	2	0	23	0	498	33	193	21	8	0	32	8
Karlovy Vary	37	61	225	431	1	0	16	404	388	1,170	1,353	2,443	563	32	146	40
Hradec Králové	25	0	7	0	4	0	13	0	48	6	100	4	30	0	15	4
Liberec	19	0	72	25	0	0	16	0	92	51	345	19	5	0	23	7
Moravia and Silesia	91	2	357	58	65	0	161	3	892	74	868	70	395	1	491	9
Olomouc	13	2	37	17	209	1	4	0	14	121	24	52	59	4	9	11
Pardubice	12	0	1	1	3	0	4	0	22	0	14	14	234	0	25	2
Plzeň	29	0	79	3	2	0	0	0	7	24	55	48	5	0	28	12
Prague	0	0	0	0	0	0	9	0	2	5	0	1	0	0	5	2
Central Bohemia	190	0	157	5	42	0	35	6	438	115	103	10	162	1	112	19
Ústí nad Labem	389	113	1,231	320	36	8	783	104	2,278	2,427	2,606	3,002	569	225	1,232	1,549
Vysočina	0	0	0	0	0	0	5	3	0	0	28	5	0	0	8	16
Zlín	29	52	0	0	0	0	3	0	103	54	49	0	355	5	36	0
Czech Republic intotal	**1,008**	**233**	**2,252**	**866**	**374**	**10**	**1,080**	**521**	**4,839**	**4,149**	**5,826**	**5,717**	**2,690**	**272**	**2,202**	**1,680**

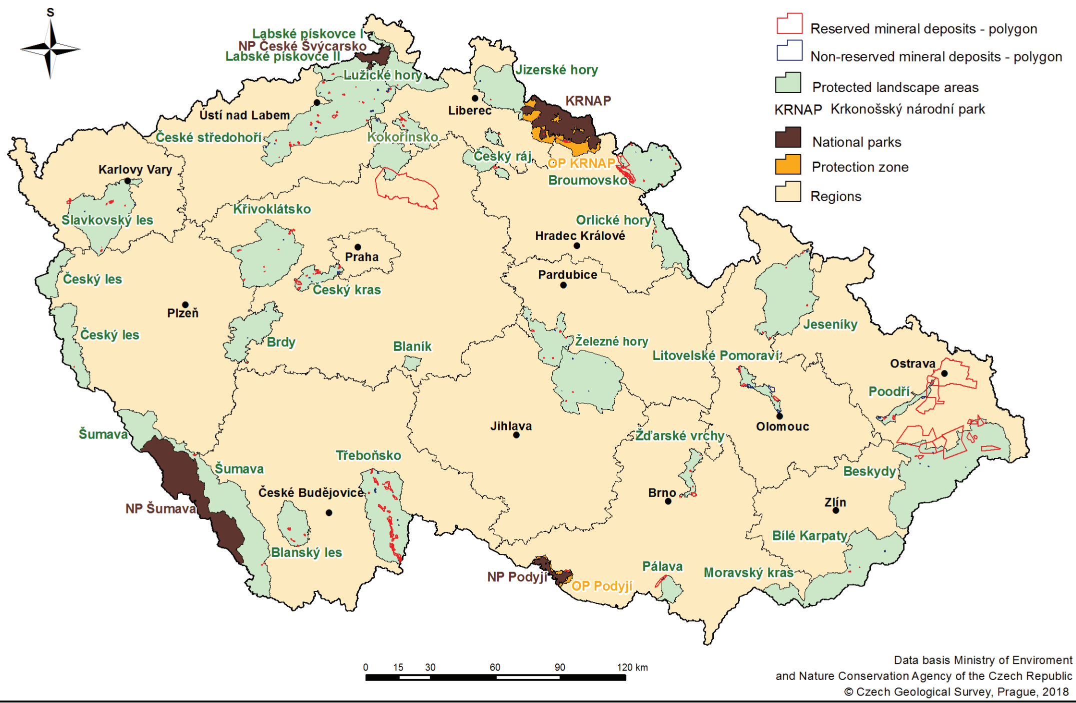
[ranked according to regions and way of reclamation; DP = mining lease (in = within, out = outside), areas in hectares (1 km^2 = 100 ha)]
** Data 2021 not available*

process. The costs incurred by such the process range between a minimum of 0.43–0.61 EUR/ m^2 (without site preparation) and a maximum of 1.36–1.87 EUR/m^2 (including distribution of substrate and further measures). In contrast to that. the costs occuring for recultivation for agricultural or forestry purposes. amount to between 1.02–3.07 EUR/m^2."

In 2009. participants in the workshop Obnova území narušených těžbou nerostných surovin ("Restoration of Mining-Impacted Land") organized by the citizens association Calla-Association for Preservation of the Environment and by the Department of Botany of the Faculty of Science at the University of South Bohemia set down principles of eco-friendly restoration of mining-impacted land (J. Řehounek (2010): Přírodovědci formulovali zásady ekologické obnovy po těžbě. /Naturalists formulated principles of post-mining ecological restoration, – Minerální suroviny/Surowce mineralne (magazine), 1: 32–33. Mining Union of the Czech Republic, Brno:

1. Prior to commencing mining. a qualified biological assessment not only of the mining area, but also of its surroundings is essential. It would be beneficial if the actual mining were to be managed, if possible, in such a way so as to preserve (possibly maintain and expand) as

MINERAL DEPOSITS IN LARGE-EXTENT SPECIALLY PROTECTED AREAS OF THE CZECH REPUBLIC NATURE (IN PROTECTED LANDSCAPE AREAS - "CHKO" AND NATIONAL PARKS)



many (semi) natural habitats in the immediate vicinity of the mine site or dumping ground. A roughly 100-metre zone in an area that can be accessed by most of the species is key for the subsequent colonization of the mining-impacted land during spontaneous succession.

2. Environmental impact assessments, biological assessments and reclamation plans, which concern the restoration of mining-impacted land and dumping grounds, should be prepared by experts, who are not only familiar with the current state of knowledge in the field of ecological restoration, but also with realistic possibilities and limits of mining technology. These problems should henceforth be included in the examinations for persons authorized to prepare environmental impact assessments pursuant to Act No. 100/2001 Coll. (EIA) and for persons certified in preparing biological assessments pursuant to § 67 of Act No. 114/1992 Coll. and in preparing assessments evaluating impacts on bird areas and on Special Areas of Conservation (SAC) pursuant to § 45i of said Act. Ongoing training in ecological restoration should be mandatory for these persons.
3. A basic restoration plan (e.g. in the form of a remediation and reclamation summary) should already be known when a mining lease (in the case of reserved deposits) is granted, or when a planning permit that designates the area for mining (in the case of non-reserved deposits) is granted, and should take into account the potential possibilities of the area. Room must be left to make any possible changes according to current conditions during the mine planning phase (plan of mine development work /POPD/ including detailed rehabilitation and reclamation plans, mining permits, etc.) and during the actual mining and completion phases.
4. It is essential to conduct another continuous assessment of the locality (a scheduled monitoring programme) already during the course of mining and after its termination, which may discover the presence of rare and endangered species and communities, as well as important geological and geomorphological phenomena. The restoration plan will have

to be modified with respect to this assessment, which should be provided by the mining company via or under supervision of a qualified person.

5. Prior to, during and after mining, it is necessary to monitor invasive species at the mine site and in its surroundings. If their presence may possibly jeopardize the intended restoration method, then they must be removed by sanitation methods.
6. The great majority of mining-impacted land can restore itself spontaneously – via spontaneous succession, which may in some cases also be guided (directed. blocked or reversed). As a rule, at least 20 % of a large mine site´s total area should be left to spontaneous succession in the most bilogically valuable areas. Smaller mining sites and dumping grounds can usually be integrated into the landscape without problem. thus ecological succession may be implemented in their entire area.
7. If endangered and specially protected species and communities are highly dependent on the mine site environment, then their population and biotypes will have to be managed appropriately. This should be covered by mandatory funds generated by the mining company for reclamation, after its completion by public funds designated for landscape programmes.
8. The most valuable mine sites and dumping grounds should be declared specially protected areas (most often classified specifically as a nature monument) and managed accordingly, or declared temporary protected areas if only temporary protection is needed. Less valuable mine sites and dumping grounds left to eco-friendly restoration should almost always at least be registered as important landscape elements. Special attention should be paid to mine sites that may be incorporated into the territorial system of ecological stability.
9. Restoration of a mine site or dumping ground should primarily increase the observable landscape diversity. It is necessary to break up straight lines and surfaces (peripheries, shore lines, etc.) with uneven areas, at the very latest after termination of (or preferably during the course of) mining. Shallow shore areas are necessary at flooded mine sites.
10. Unsuitable pieces of equipment and waste should removed after mining is terminated if the aim is to integrate a mine site or dumping ground into the environment.
11. The nutrient-rich top soil sections must be permanently removed from those parts of the mine site that are designated for eco-friendly restoration in the least amount of time. This already needs to be taken into account during the reclamation planning phase. As overburden is returned, so are excess nutrients, which mostly support the evolution of a few less abundant, agressive species, including invasive ones. Once mining commences it is therefore necessary to verify, in collaboration with protection of agricultural land resources authorities (hereinafter OZPF), if the overburden is being carefully and completely removed from areas designated for eco-friendly restoration. Otherwise it is necessary to modify the implementation of the reclamation plan, again however in collaboration with OZPF and mining authorities.
12. From an environmental protection perspective, phased mining and restoration works best at larger mine sites, specifically when spread out over a longer period so that abandoned areas of the mining area are gradually left to restoration. This procedure helps create more varied and higher-quality communities with regard to age and extent in restored areas.
13. It is beneficial to place permanent study areas designated for scientific research, testing of eco-friendly interventions and monitoring in all types of mining areas. These areas should be respected by the mining companies.

Conclusion of the workshop: EEco-friendly restoration of mining-impacted land is certainly not the only option of how to deal with the integration of these areas into the landscape. Our laws should however allow for this restoration method, which is common in many countries, to become an equivalent alternative to the thus far predominant forest and agricultural reclamations.

In 2011. a final report on project VaV SP/2d1/141/07 “Rekultivace a management nepřírodních biotopů v České republice” (“Reclamation and Management of Non-Natural Biotypes in the Czech Republic”) was published for the entire duration of the project in 2007 – 2011 carried out by the Institute for Environmental Policy, Public Benefit Corporation, by the Institute of Geology of the Academy of Sciences of the Czech Republic, Public Research Institution and by the Czech University of Life Sciences Prague. Its fi and recommendations state among other things:

“Areas impacted by mining and by some other human activities such as quarries, sand pits, mining sites of kaolin and brick clays, waste piles/dumps and large waste depots, are by far not really devastated. dead “lunar landscapes“. On the contrary, it is being demonstrated that, in terms of the protection of diverse biotypes, they are a very important refuge, where mushrooms and wild plants and animals are finding optimum living conditions, which they entirely lack in urbanized and industrial areas. and on land used intensively by agriculture, ...

It is absolutely vital that the relevant state administration authorities respond appropriately to the new scientific findings. In the next legislative session, they should in collaboration with experts prepare and put into practice appropriate changes to laws and executive regulations, which regulate mining and other related human activities, primarily remediation and reclamation. The following legal regulations must be amended:

- Act No. 44/1988 Coll., on mineral protection and use (the Mining Act) – subsequently amended;
- Regulation of the ČBÚ No. 172/1992 Coll., on mining leases in the wording of the Regulation No. 351/2000 Coll.;
- Regulation of the ČBÚ No. 104/1988 Coll., on efficient use of reserved deposits. on permits and notification of mining operations and other activities employing mining methods – subsequently amended;
- Act No. 61/1988 Coll., on mining operations, explosives and the state mining – subsequently amended;
- Act No. 334/1992 Coll., on protection of agricultural land resources – subsequently amended
- Regulation of the MŽP ČR No. 13/1994 Coll., governing some details of agricultural land resources protection – subsequently amended;
- Regulation of the ČBÚ No. 13/1994 Coll., on efficient use of reserved deposits. on permits and notification of mining operations and other activities employing mining methods – subsequently amended;
- Act No. 289/1995 Coll., on forests, modifying and amending certain acts (the Forest Act);
- Regulation of the Ministry of Agriculture of the Czech Republic No. 77/1996 Coll., on necessary elements of applications for dispossession or curtailment of rights. and on details of protection of lands devoted to forest function performance – subsequently amended;
- Act No. 114/1992 Coll., on nature and landscape protection – subsequently amended.

These unavoidable changes should eliminate evident discrepancies and deficiences in the legislation concerning the areas in question and harmonize legal regulations, so that ecological

Share of specially Protected Areas of the Czech Republic nature (zvláště chráněná území přírody České republiky (ZCHÚs)) established in localities with former mining ("after mining") in all the ZCHÚs
(compiled after data of the Nature Conservation Agency of the Czech Republic – AOPK ČR in 2022)

Region	Number of ZCHÚs (without CHKOs)	Area of ZCHÚs (without CHKOs) (ha)	Number of ZCHÚs "after mining"	Area of ZCHÚs (without CHKOs) "after mining" (ha)	Share of ZCHÚ areas "after mining" in the all ZCHÚs (without CHKOs) area	Share of ZCHÚ number "after mining" in the all ZCHÚs (without CHKOs) number
	data 2021	**data 2021**	**data 2013***	**data 2013***	**data 2013*/ data 2021**	**data 2013*/ data 2021**
Central Bohemia	309	16,999	41	817.99	4.81 %	13.26 %
Prague	93	2,432	36	714.04	29.36 %	41.94 %
Karlovy Vary	94	5,905	6	33.03	0.56 %	6.38 %
Olomouc	165	7,636	20	195.88	2.57 %	12.12%
South Moravia	343	11,477	23	343.00	2.99 %	6.71%
Pardubice	110	6,220	5	116.84	1.88 %	4.45 %
Plzeň	196	6,809	17	148.09	2.17 %	8.67 %
Zlín	215	2,582	6	23.72	0.92 %	2.79 %
Moravia and Silesia	167	8,727	17	264.81	3.03 %	10.18 %
Liberec	126	5,903	6	244.38	4.14 %	4.76 %
Vysočina	204	5,923	4	29.25	0.49 %	1.96 %
Ústí nad Labem	182	9,951	12	327.79	3.29 %	6.59 %
Hradec Králové	135	8,829	6	17.10	0.19 %	4.44 %
South Bohemia	343	16,464	18	247.24	1.50 %	5.25 %
Czech Republic total	**2,668**	**115,859**	**217**	**3 523.16**	**3.04 %**	**8.13 %**

** data from 2013 onwards are not available*

and economic highly effective nature-friendly methods of restoration based on natural or directed ecological succession may be used to a greater extent..."

The conclusions and recommendations expressed in the final report of the project "Reclamation and Management of Non-Natural Habitats in the Czech Republic" were overwhelmingly fulfilled from the legislative point of view and most of the laws and decrees were recently amended. We state the status of amendments to this legislation in 2021:

- Act No. 44/1988 Coll., on mineral protection and use (the Mining Act) – novelization is the Act No. 88/2021Coll., with effect from 16. 3. 2021;
- Regulation of the ČBÚ No. 351/2000 Coll., on mining leases in the wording – without change
- Regulation of the ČBÚ No. 104/1988 Coll., on efficient use of reserved deposits. on permits and notification of mining operations and other activities employing mining methods – novelization is the Act No. 403/2020 Coll. and the Act No. 609/2020 Coll., with effect from 1. 1. 2021;
- Act No. 61/1988 Coll. on mining operations. explosives and the state mining – novelization is the Act No. 91/2018 Coll., with effect from 15. 6. 2018;
- Act No. 334/1992 Coll. on protection of agricultural land resources – novelization is the Act No. 82/2017 Coll. with effect from 1. 1. 2018;
- Regulation of the MŽP ČR No. 13/1994 Coll., governing some details of agricultural land resources protection – novelization is the Regulation of the MŽP No. 153/2016 Coll., with effect from 1. 6. 2016;
- Act No. 289/1995 Coll., on forests. modifying and amending certain acts (the Forest Act) –
- novelization is the Act No. 225/2017 Coll., with effect from 1. 1. 2018;
- Regulation of the Ministry of Agriculture of the Czech Republic No. 77/1996 Coll., on necessary elements of applications for dispossession or curtailment of rights. and on details of protection of lands devoted to forest function performance – without change
- Act No. 114/1992 Coll., on nature and landscape protection – novelization is the Act No. 225/2017 Coll., with effect from 1. 1. 2018.

Publication *Řehounek J., Řehounková K., Prach K. (editoři[eds]) (2010): Ekologická obnova území narušených těžbou nerostných surovin a průmyslovými deponiemi, – Calla. České Budějovice. [Ecological reclamation of regions disturbed by minerals mining and industrial stockpiles.]* keeps to the conclusions of the workshop.

Eliminating negative consequences of mining in the Czech Republic – major methods and financial resources

Ing. Vít Kaštovský, Ph.D., Kateřina Trnková, Ing. Marcela Hrúzová
Ministry of Industry and Trade of the Czech Republic

Introduction

The process of restructuring coal and ore mining, and of eliminating negative environmental consequences of mining in the landscape and erasing these consequences in affected areas of the Czech Republic, is executed in several ways and with various financial resources. It specifically involves:

1. Use of funds from a financial reserve generated by mining companies for remediation, reclamation, and mining damages
2. Use of funds from annual royalties paid by mining companies on mining leases and on extracted reserved minerals pursuant to the Mining Act
3. Phase-out programme of mining activities and erasing consequences of coal, ore and uranium mining funded by the national sources via the Ministry of Industry and Trade
4. Use of proceeds from privatisation of state assets in eliminating old ecological burdens caused by mining, existing prior to privatisation of mining companies
5. A programme which deals with ecological damage caused prior to privatisation of brown coal mining companies in the Ústí nad Labem Region and Karlovy Vary Region, with ecological revitalisation upon termination of mining operations in the Moravia and Silesia Region, with eliminating ecological burdens caused by the exploration for and extraction of crude oil and natural gas in designated areas of the South Moravian Region, and with reducing the impacts caused by the termination of coal mining in the Kladno Region based on Government resolutions in 2002. Funds are provided by proceeds from privatisation of national assets.

1. Use of funds from a financial reserve generated by mining companies for remediation, reclamation, and mining damages

Financial reserve for remediation and reclamation

The most important source for funding the elimination of the consequences of mining operations in the Czech Republic is the financial reserve for remediation and reclamation, generated by mining companies during the exploitation of reserved mineral deposits.

The amendment to Mining Act No. 88/2021 Coll., under Article 37a Section 1 a), imposes on the mining company to generate a financial reserve to ensure rehabilitation and reclamation of land affected by mining.

For the purposes of this Act, remediation means bringing the area affected by the effects of mining activities to a stable and safe condition that will allow reclamation to be carried out in accordance with Act No. 334/1992 Coll., on the protection of the agricultural land fund, as amended, and Act No. 289/1995 Coll., on forests and on amendments to certain acts (Forest Act), as amended; remediation includes the technical decommissioning of a mine or quarry.

Remediation of land vacated during mining is carried out according to the layout, preparation and mining plan.

For the purposes of this Act, the technical decommissioning of a mine or quarry shall mean the placing of the mining operations resulting from mining activities in a condition that will not create a safety risk or a risk of environmental damage or accident. The technical decommissioning of a mine or quarry also includes structures and subsurface objects whose removal is necessary to carry out remediation and reclamation or which are part of the main mining operations.

Pursuant to article 32 section 2 of the Mining Act, the determination of anticipated expenses for remediation and reclamation is part of the plan for opening, preparation and exploitation of reserved deposits (hereinafter referred to as "POPD"), and the POPD must also contain a proposal regarding the amount of, and the method for, generating the required financial reserve.

Section 37a(1)(b) of the amended Mining Act No 88/2021 requires the mining organisation to create a reserve of funds to ensure the settlement of mining damage.
The amount of the reserves must correspond to the needs for the settlement of mining damage, including in terms of the expected duration of their use. The creation, drawing, collection, transfer and cancellation of reserves are subject to the approval of the District Mining Office.

Financial reserve for mining damages

By amendment to the Mining Act No. 88/2021 Coll. was in § 37a paragraph 1 letter b) ordered the mining organization to create a reserve of funds, namely to ensure the settlement of mining damages.

The reserve amount generated and charged to expenses must correspond to the needs for settling mining damages in the course of time depending on their creation, or prior to their creation.

The reserve funds for the settlement of mining damage and for remediation and reclamation are deposited in a special escrow account under the law governing reserves for the determination of the income tax base, maintained in the Czech Republic with a bank or a branch of a foreign bank established in another Member State of the European Union, by 30 June of the calendar year following the end of the relevant accounting period. In the event that the organisation fails to do so, the District Mining Office shall set a reasonable alternative time limit. Reserve funds may not be subject to collateral, are not part of the taxpayer's assets in insolvency proceedings and are not subject to enforcement or execution. The agreement on the special escrow account must clearly indicate that it is a special escrow account maintained for the purposes of this Act and for the purposes of which reserve it is established.

2. Use of funds from annual royalties paid by mining companies on mining leases and on extracted reserved minerals pursuant to the Mining Act

Reimbursements on mining leases

Since 1 January 2017, the payments and rates of reimbursements from mining leases are regulated by Act No. 89/2016 Coll., which amends Act No. 44/1988 Coll., on the Protection and Use of Mineral Resources, as amended (the Mining Act). The holders of mining areas have the obligation to pay an annual payment from the mining area to the account of the

Generated and drawn reserves for remediation and reclamation (in CZK thousand)

Year	Bituminous coal		Brown coal		Crude oil and natural gas		Ores		Industrial minerals		Radioactive minerals		Total	
	generated	drawn	generated	drawn	generated	drawn	generated	drawn	generated	drawn	generated	drawn	generated	drawn
1993	118,500	0	1,341,769	65,615	12,722	0	0	0	97,438	8,236	0	0	1,570,429	73,851
1994	123,750	18,600	573,242	259,929	6,836	0	0	0	255,155	30,335	0	0	958,983	308,864
1995	85,895	136,064	3,845,935	265,856	22,414	370	0	0	276,724	24,230	0	0	4,230,968	426,520
1996	143,500	97,993	1,436,957	831,817	25,811	113	0	0	270,432	31,829	0	0	1,876,700	961,752
1997	108,000	42,108	1,302,735	1,087,993	62,618	5,569	0	0	484,420	53,262	0	0	1,957,773	1,188,932
1998	51,594	48,033	1,226,036	994,133	22,112	9,541	0	0	466,649	59,913	0	0	1,766,391	1,111,620
1999	132,143	56,236	1,199,633	704,199	26,181	7,473	0	0	318,852	141,530	0	0	1,676,809	909,438
2000	42,747	52,029	1,119,474	683,179	23,487	600	0	0	307,433	140,225	0	0	1,493,141	876,033
2001	876,194	77,458	1,267,431	678,515	23,184	2,750	390	0	215,379	53,893	0	0	2,382,578	812,616
2002	887,250	129,600	1,007,561	653,557	100	250	0	0	157,721	50,604	0	0	2,052,632	834,011
2003	1,800	498	5,199,919	4,844,371	11,782	1,050	0	0	179,763	57,848	0	0	5,393,264	4,903,767
2004	65,002	54,162	1,031,828	720,168	4,770	0	0	0	160,102	73,177	0	0	1,261,702	847,507
2005	66,504	54,204	964,222	547,883	17,524	9,409	0	0	228,713	113,743	0	0	1,276,963	725,239
2006	74,178	113,691	845,008	663,055	17,893	3,300	0	0	144,665	92,489	0	0	1,081,744	872,535
2007	32,696	88,462	718,820	240,060	25,417	17,259	0	0	127,413	82,329	0	0	904,346	428,110
2008	17,660	66,941	626,649	330,397	24,828	16,372	0	0	233,615	99,610	0	0	1,008,637	513,320
2009	21,780	69,711	650,696	394,528	15,454	1,324	0	0	177,681	77,290	0	0	955,897	542,853
2010	22,800	147,848	298,205	133,171	16,302	461	0	0	96,207	94,517	0	0	433,515	375,997
2011	22,500	170,958	625,011	491,068	22,336	986	0	0	82,252	87,681	0	0	752,099	750,693
2012	22,500	141,432	632,601	364,264	9,871	1,693	0	0	96,263	91,721	0	0	761,235	599,110
2013	15,000	240,951	648,019	325,791	13,530	2,044	0	0	86,121	57,478	0	0	762,670	626,254
2014	15,000	204,020	612,459	470,297	11,566	1,341	0	0	84,084	40,704	0	0	723,109	716,362
2015	15,000	108,188	577,398	518,197	12,131	809	0	0	98,192	70,309	0	0	702,721	697,503
2016	13,000	163,255	602,096	381,520	12,676	1,562	0	0	83,754	62,752	0	0	711,526	609,089
2017	90,000	131,195	612,635	465,305	11,879	550	0	0	76,948	49,832	0	0	791,462	637,882
2018	150,000	128,142	408,487	449,587	11,680	408	0	0	87,395	65,824	0	0	657,562	643,981
2019	75,000	82,418	348,379	383,474	11,190	658	0	0	90,726	40,302	0	0	525,285	506,852
2020	0	37,688	468,404	418,926	44,307	66,178	0	0	86,415	43,973	0	0	599,126	566,765
2021	0	45,247	476,341	562,068	10,188	0	0	0	92,656	50,647	0	0	579,185	657,962

Source: Czech Mining Authority

relevant district mining office. The rate of the reimbursement from the mining lease is CZK 300 per hectare or CZK 1,000 per hectare if the mining activity in the mining lease is allowed, consisting in the preparation, opening and extraction of the reserved deposit. A calendar year is the payment period.

Generated and drawn reserves for mining damages (in CZK thousand)

Year	Bituminous coal		Brown coal		Crude oil and natural gas		Ores		Industrial minerals		Radioactive minerals		Total	
	generated	drawn	generated	drawn	generated	drawn	generated	drawn	generated	drawn	generated	drawn	generated	drawn
1993	400,721	4,093	150,548	42,957	0	0	0	0	28,462	0	0	0	579,731	47,050
1994	105,650	38,813	50,000	32,223	0	0	0	0	9,328	28,852	0	0	164,978	99,888
1995	204,785	86,001	209,207	37,748	0	0	0	0	10,673	9,394	0	0	424,665	133,143
1996	151,643	74,952	259,779	84,258	0	0	0	0	13,100	3,407	0	0	424,522	162,617
1997	77,900	142,512	318,981	127,715	0	0	0	0	5,733	683	0	0	402,614	270,910
1998	185,723	174,640	252,920	112,852	0	0	0	0	16,043	3,638	0	0	457,686	291,130
1999	111,588	174,640	212,722	40,448	0	0	0	0	10,803	6,844	0	0	335,113	221,932
2000	110,088	107,852	240,655	188,685	0	0	0	0	11,414	1,020	0	0	362,157	297,557
2001	145,750	188,073	105,513	217,306	192	0	100	0	35,877	6,628	0	0	287,432	412,007
2002	102,750	168,531	102,700	510,200	0	0	0	0	2,327	2,338	0	0	207,777	681,069
2003	0	0	816,197	999,271	90	0	0	0	12,576	2,263	0	0	828,863	1,001,534
2004	187,700	139,714	164,700	315,321	0	0	0	0	3,007	4,560	0	0	355,407	459,595
2005	191,700	143,974	97,433	279,955	0	0	0	0	6,597	4,273	0	0	295,730	428,202
2006	285,780	251,941	522,908	1,334	150	0	0	0	4,517	6,846	0	0	813,355	260,121
2007	260,850	190,982	193,147	932,392	30	0	0	0	4,298	3,831	0	0	458,325	1,127,205
2008	304,700	308,593	64,601	155,924	0	0	0	0	3,739	2,788	0	0	373,040	467,305
2009	317,625	282,928	30,200	25,800	0	0	0	0	3,447	1,216	0	0	351,272	309,944
2010	283,008	173,686	25,034	15,730	100	0	0	0	2,644	1,514	0	0	310,786	190,930
2011	468,508	196,012	25,663	25,248	100	0	0	0	2,695	2,595	0	0	496,966	223,855
2012	811,202	741,987	30,000	5,818	100	0	0	0	6,157	3,325	0	0	847,459	751,130
2013	145,000	131963	30,000	0	0	0	0	0	3,378	2,724	0	0	178,378	134,686
2014	75,000	183,517	57,391	60,201	50	0	0	0	15,495	3,330	0	0	145,833	245,339
2015	75,000	148,989	35,000	67,096	50	0	0	0	5,076	13,212	0	0	115,126	229,297
2016	30,000	106,673	15,161	36,307	50	0	0	0	3,437	3,250	0	0	48,648	146,230
2017	120,000	109,000	1,666	99,798	247	0	0	0	1,244	2,613	0	0	123,157	211,763
2018	150,000	210,155	430,000	361,029	0	0	0	0	3,493	1,832	0	0	583,493	573,016
2019	150,000	180,256	210,000	996,547	0	0	0	0	2,570	1,598	0	0	362,570	1,178,401
2020	0	105,299	80,003	326,767	0	0	0	0	2,419	1,232	0	0	82,423	433,298
2021	0	113,871	40,669	154,427	0	0	0	0	2,467	1,592	0	0	43,136	269,890

Source: Czech Mining Authority

The ultimate recipient of the mining lease royalties are the municipalities in whose territory the mining lease is located. These resources are used, in large measure, as compensation for negative impacts of mining on the municipalities in question.

As shown in the following table, approx. CZK 894.0 million was paid out to municipalities since the inception of royalties payments on mining leases in 1993 till 2021.

Reimbursements from mining lease areas paid out to municipalities pursuant to Article 32a) Sec. 1 of the Mining Act (in CZK thousand) CZK

Year	Number of municipalities	Total
1993	1,327	25,929
1994	1,194	22,752
1995	1,168	24,114
1996	1,225	24,032
1997	1,191	23,446
1998	1,269	22,885
1999	1,208	23,629
2000	1,178	23,780
2001	1,171	23,728
2002	1,168	22,899
2003	1,158	21,740
2004	1,161	21,511
2005	1,138	21,077
2006	1,127	16,178
2007	1,118	15,512
2008	1,305	15,127
2009	1,239	14,925
2010	938	14,032
2011	885	13,888
2012	939	13,809
2013	918	13,800
2014	918	13,800
2015	919	13,800
2016	917	13,688
2017	935	96,304
2018	901	88,150
2019	894	83,384
2020	898	83,297
2021	898	82,823
Total		**894,039**

Source: Czech Mining Authority

Royalties on extracted reserved minerals

The payments and royalty tariffs from extracted minerals are regulated by Act No. 88/2021 Coll., which amends Act No. 44/1988 Coll., on Mineral protection and use, as amended and by Government Provision No. 98/2016 Coll., on the royalty tariffs.

The royalty tariffs from extracted minerals for individual sub-bases of reimbursement stipulated in the Government Regulation amounts at most to 10% of the market price per unit of quantity for each species of extracted minerals or individual utility components. A calendar year is the payment period.

Distribution of royalties on extracted reserved minerals pursuant to Article 32a) Sec. 4 of the Mining Act (in CZK thousand)

Year	50% SB (State budget)			50% Municipalities	Total
1993	230,400			230,526	460,926
1994	245,762			245,276	491,038
1995	221,909			221,566	443,475
1996	229,703			229,703	459,406
1997	228,874			228,874	457,748
1998	220,885			220,886	441,771
1999	219,938			219,938	439,876
2000	227,778			227,859	455,637
Total	**1,825,249**			**1,824,628**	**3,649,877**
	12.5 % MIT	**12.5 % MoE**		**75 % Municipalities**	
2001	153,166	12,500		302,221	467,887
2002	55,000	59,500		356,724	471,224
2003	61,713	61,800		371,827	495,340
2004	70,000	69,500		393,695	533,195
2005	76,398	76,700		449,135	602,233
2006	76,305	76,400		455,947	608,652
2007	82,716	82,300		494,737	659,753
2008	84,367	84,250		505,782	674,399
2009	80,720	80,720		484,556	645,996
2010	73,023	73,023		435,103	581,149
2011	80,714	80,714		484,284	645,712
2012	78,711	78,711		472,266	629,688
2013	74,554	74,554		447,323	596,430
2014	73,146	73,146		438,875	585,167
2015	64,699	64,699		388,193	517,591
2017	54,290	54,290		325,740	434,319
	State budget			**Municipalities**	
	Czech Mining Authority 60 %	**28 % MIT**	**12 % MoE**		
2017	325,725	152,003	65,148	385,613	928,489
2018	330,012	154,006	66,002	387,013	937,033
2019	309,822	144,584	61,964	346,839	863,209
2020	260,679	121,650	52,136	301,062	735,527
2021	268,289	125,201	53,658	307,948	755,096
Total 1993–2021					**17,017,966**

Source: Czech Mining Authority

Part of the yield of the royalty from the extracted minerals in the amount of

a) a partial royalty of quarried brown coal –
   1. 33 % is allocated to the budget of the municipality in whose territory brown coal quarrying was carried out, and
   2. 67 % is allocated to the state budget,

b) partial royalties from extracted brown coal or black coal –
   1. 75 % is allocated to the budget of the municipality in whose territory the mining of black coal or brown coal was carried out, and
   2. 25 % is allocated to the state budget

c) partial royalty from radioactive minerals –
   1. 75 % is allocated to the budget of the municipality in whose territory the mining of radioactive minerals was carried out, and
   2. 25 % is allocated to the state budget,

d) partial royalties from oil or from flammable natural gas –
   1. 75 % is allocated to the budget of the municipality in whose territory the extraction of oil or natural gas was carried out.
   2. 25 % is allocated to the state budget or

e) other partial royalties –
   1. 38 % is allocated to the budget of the municipality in whose territory mining of other minerals was carried out, and
   2. 62 % is allocated to the state budget.

3. Phase-out programme of mining activities and erasing consequences of coal, ore and uranium mining funded by the national sources

The restructuring of industry in the Czech Republic, specifically of metallurgy and engineering, initiated after 1989, had an immediate impact on the mining sector. Uneconomic ore, coal and uranium mining, and a lower raw material demand were the decisive reasons for the restructuring and subsequent privatisation of mining companies. Part of the restructuring of the mining industry was the announcement of a phase-out of mining activities in uneconomic underground mines and quarries.

The essential method of funding the restructuring of the mining sector is provided by subsidies from the state budget, in accordance with relevant Government resolutions, for the phase-out and to erase the consequences of mining operations.

In the initial phase, the phase-out in individual branches of mining occurred independently, mainly because mining companies reported to various departments.

The phase-out of uranium mining was already decided upon in 1989, as based on documents processed by the Federal Ministry of Fuel and Energy, which was approved by ČSSR (Czechoslovak Socialist Republic) Government Resolution No. 94/1989 on the concept of lowering the unprofitability of uranium mining in the ČSSR in 1990, in the 9th and 10th five-year plans by phasing it out. This Government resolution from 1990 was subsequently amended by the Government of the ČSFR (Czechoslovak Federal Republic) with new Government Resolution No. 894/1990 regarding the modification of the phase-out concept for uranium mining in the ČSFR.

In 1990, ore mining was integrated into the Federal Ministry of Metallurgy, Engineering and Electric Engineering which, for the purpose of dealing with ore mining and the announcement

Use of national sources subsidies for the phase-out of mining and to erase consequences of mining and mandatory social health expenses (in CZK million)

Year	Mining in total			Coal mining			Ore mining			Uranium mining		
	TPO	MSHE	total	TPO	MSHE	total	TPO	MSHE	total	TPO	MSHE	total
1992	1 100,3	0	1 100,3	555,7	0	555,7	248,0	0	248,0	296,6	0	296,6
1993	2 555,1	1 436,3	3 991,4	1 816,1	949,7	2 765,8	43,2	189,0	232,2	695,8	297,6	993,4
1994	3 940,1	1 528,0	5 468,1	2 333,4	1 011,7	3 345,1	35,1	179,6	214,7	1 571,5	336,7	1 908,2
1995	3 861,1	1 678,1	5 539,2	1 956,8	1 329,9	3 286,7	198,8	36,4	235,2	1 759,3	346,4	2 105,7
1996	3 755,5	1 823,2	5 578,7	2 168,3	1 422,7	3,591,0	126,7	33,0	159,7	1 486,9	367,0	1 853,9
1997	2 305,9	1 811,1	4 117,0	1 364,6	1 362,8	2 727,4	100,1	34,9	135,0	836,6	413,4	1 250,0
1998	2 571,7	1 862,9	4 434,6	1 690,2	1 403,7	3 093,9	94,8	30,2	125,0	979,7	422,9	1 402,6
1999	2 073,5	1 955,8	4 029,3	1 206,1	1 475,9	2 682,0	79,2	37,6	116,8	787,9	442,2	1 230,1
2000	2 064,2	1 986,1	4 050,3	1 193,8	1 475,2	2 669,0	158,0	30,2	188,2	712,3	474,9	1 187,2
2001	2 296,2	1 955,6	4 251,8	1 118,4	1 451,0	2 569,4				1 174,6	500,4	1 675,0
2002	1 729,9	1 913,8	3 643,7	574,9	1 359,2	1 934,1		part of the uranium mining		1 154,8	553,3	1 708,1
2003	2 148,5	1 751,1	3 899,6	654,4	1 294,2	1 948,6				1 494,1	455,5	1 949,6
2004	2 576,1	1 713,2	4 289,3									
2005	2 110,3	1 669,1	3 779,4									
2006	2 069,8	1609,3	3 679,1									
2007	1 917,9	1 574,1	3 492,0									
2008	1 971,9	1 465,7	3 437,6									
2009	2 027,4	1 383,5	3 410,9									
2010	2 281,0	1 257,6	3 538,6									
2011	2 557,1	1 149,6	3 706,7									
2012	2 717,8	979,4	3 697,2									
2013	2 428,0	855,9	3 283,9					With the merger of s. p. Rudné doly Příbram with s. p. DIAMO and the takeover of phased out areas of OKD, a. s., monitoring on an industry-by-industry basis was terminated.				
2014	2 768,8	744,5	3 513,3									
2015	2 672,0	641,6	3 313,6									
2016	2 515,1	551,9	3 067,0									
2017	3 121,6	543,2	3 664,8									
2018	3 275,8	494,4	3 770,2									
2019	2 716,3	408,9	3 125,1									
2020	3 336,8	289,7	3 626,5									
2021	4 922,5	250,4	5 172,9									
Total	**78 388,2**	**37 284,0**	**115 672,2**	**16 632,7**	**14 536,0**	**31 168,7**	**1 083,9**	**570,9**	**1 654,8**	**12 950,1**	**4 610,3**	**17 560,4**

Source: MIT
TPO – technical work related to phase-out and erasing consequences of mining operations
MSHE – mandatory social health expenses

of a phase-out programme for the ore mining industry as of 1 July 1990, processed documents for Government proceedings and Government Resolution No. 440/1990 was adopted.

The phase-out of coal mining was announced at the end of 1992 based on Government Resolution No. 691/1992 concerning the programme for restructuring the coal industry, and documents for Government proceedings were processed by the Ministry of Industry and Trade.

Even though the phase-out of ore mining was not completed, a merger of Rudné doly Příbram state enterprise with DIAMO state enterprise occurred as of 1 January 2001, thereby ending the industry-by-industry monitoring of the phase-out, i.e. ore and uranium mining.

Another modification of the reporting method concerning the drawing on state budget funds occurred in 2003, when, in addition to the proposed state participation in the completion of the restructuring of coal mining, Government Resolution No. 395/2003 authorised the transfer of the Barbora locality from OKD, a. s. company to DIAMO state enterprise, and the localities of Ležáky, Kohinoor and of Kladenské doly to Palivový kombinát Ústí state enterprise.

Since the initiation of the phase-out of mining in 1992, a total of app. CZK 115,672.2 million was released from the state budget for the phase-out of mining and to erase the consequences of mining. As shown in the table above, app. CZK 78,378.2 million were spent on technical works related to the phase-out of mining and on erasing the consequences of mining operations, and app. CZK 37,284.0 million on social health benefits for miners.

Overview of entities with which "ecological contracts" were entered into, including guaranteed financial volumes and their actual drawn amount (in CZK) – as of 05/31/2021

Name of mining company	Amount of guarantee	Drawn from guarantee	Amount available for drawing
DIAMO, státní podnik	4,200,000,000	3,440,114,023.55	759,885,976.45
DIAMO, státní podnik	3,797,000,000	3,787,286,690.79	On December 1, 2014 an environmental contract terminated by fulfillment
DIAMO, státní podnik	32,000,000,000	9,330,192,380.03	On 31 December 2018 environmental contract was executed, funding transferred to the MIT
OKK Koksovny, a.s.	27,800,000,000	2,855,709,181.89	24,944,290,818.11
Sokolovská uhelná, právní nástupce, a.s.	214,000,000	206,284,986.31	7,715,013.69
Severočeské doly, a.s.	172,265,000	9,561,927.38	162,703,072.62

*) *Government Resolution No. 483/2010, point II. 2. approved the Government to finance the rehabilitation of the former uranium chemical mining mine in Stráž pod Ralskem, up to CZK 32 billion, from the so-called Privatization Fund. Pursuant to this Government Resolution, the Ministry of Finance concluded a contract No. 5541-2012-452-S-0254/12/01 with the state enterprise DIAMO on the reimbursement of costs and expenses related to the management of the consequences of chemical uranium mining and related activities in the Stráž pod Ralskem for the period from 2012 to 2042 with financial performance of up to CZK 32 billion, of which a total of CZK 9 330 million, including supervision activities, has been used so far. The Environmental Contract No. 5541-2012-452-S-0254/12/01 was terminated as of 31 December 2018, and as of 1 January 2019, according to Government Resolution No. 610 of 4 September 2017, the action will be paid from the state budget chapter No. 322 – Ministry of Industry and Trade.*

4. Exploitation of proceeds from the sale of privatised property and profit from state participation in companies to remove old ecological burdens incurred prior to the privatisation of mining companies

Based on a decision by the Czech Republic Government, the former National Property Fund of the Czech Republic (as of 1 January 2006 the Ministry of Finance, based on Act No. 178/2005 Coll. and Act No. 179/2005 Coll.) pledged, by virtue of "ecological contracts" entered into with particular individual assignees of assets from privatisation, to eliminate old ecological burdens created prior to privatisation by the use of its privatisation proceeds.

The procedures and process principles for implementing measures leading to remediation of old ecological burdens created prior to privatisation are established in accordance with Government Resolution No. 51 dated 10 January 2001.

The process adheres primarily to the following Acts and Resolutions of the Czech Republic Government:

a) Act No. 92/1991 Coll., on the terms and conditions regarding the transfer of state assets to other persons, as amended;
b) Act. No. 178/2005 Coll., on the National Property Fund of the Czech Republic liquidation and on on the responsibility of Ministry of Finance during privatisation Czech Republic assets (Act on the National Property Fund liquidation), as amended;
c) Act No. 308/2018 amending Act No. 178/2005 Coll., on the abolition of the National Property Fund of the Czech Republic and on the competence of the Ministry of Finance in the privatization of the Czech Republic's assets (Act on the abolition of the National Property Fund), as amended; some other related laws
d) Act No. 179/2005 Coll., which amends some laws in connection with adopting the Act on the National Property Fund liquidation, as amended;
e) Government Resolution No. 51 from 10 January 2001, which contains the appendix entitled Principles for Settlement of Ecological Obligations Arising during Privatisation (hereinafter Principles), as amended;
f) Government Resolution No. 565/2006 on Principles during completion of privatisation pursuant Act No. 92/1991 Coll., on the terms and conditions regarding the transfer of state assets to other persons and Act No. 178/2005 Coll., on the National Property Fund of the Czech Republic liquidation and on on the responsibility of Ministry of Finance during privatisation Czech Republic assets, as amended;
g) Act No. 134/2016 Coll., on Awarding Public Contracts, as amended.

The processing of the programme is always provided by the Ministry of Finance. The Ministry of the Environment provides a guaranteed expertise in the process, it issues binding opinions to the individual procedural steps of implementation in accordance with „MF and MoE Directive No. 4/2017 on preparation and implementation of contracts addressing environmental obligations in privatisation". Mutual collaboration of both authorities in the implementation process is regulated by the "Rules for Mutual Collaboration of the Ministry of the Environment and the Ministry of Finance in the Awarding of 'Ecological Contracts' to Eliminate Old Ecological Damage".

Elimination of old ecological damage created prior to privatisation proceeds for the most part according to priorities established by the MoE (Ministry of the Environment) with regard to the state of preparedness of their documents for the tender procedure.

5. A programme dealing with ecological damage caused prior to privatisation of brown coal mining companies in the Ústí nad Labem Region and the Karlovy Vary Region, with ecological revitalisation upon termination of mining in the Moravia and Silesia Region, with eliminating ecological burdens caused by the exploration for and extraction of crude oil and natural gas in designated areas of the South Moravian Region, and with reducing impacts caused by the termination of coal mining in the Kladno Region based on Government resolutions in 2002 and 2008. The source of funding includes the proceeds from the sale of privatised assets and the profit from state participation in companies

After the privatisation of mining companies, the financial settlement of related ecological damage was not resolved in an appropriate manner, within the scope of privatisation projects. However, within the scope of privatisation, companies took over not only mining localities but also extensive areas from the state, which were designated for revitalisation and for which a required financial reserve was not generated in the past.

Mining companies are only obliged to generate a financial reserve for remediation and reclamation of areas affected by mining since 1994, and that on the basis of Amendment (No. 168/1993 Coll.) of the Mining Act.

In 2002, the Czech Republic Government being aware of this fact began to intervene financially in the ecological and partially economic revitalisation of regions with active or terminated mining operations. The aim was to remedy the environmental damage caused by mining operations prior to implemented legal regulation. For this purpose it earmarked:

- CZK 15 billion from the proceeds from sale of assets designated for privatisation and from the profits of public enterprises to deal with ecological damage created prior to privatisation of brown coal mining companies in the Ústí nad Labem Region and Karlovy Vary Region – Government Resolution No. 625/2017 increased the limit for drawing to CZK 18 billion.,
- CZK 20 billion to deal with ecological damage caused by mineral mining, primarily underground mining of bituminous coal in the Moravia and Silesia Region, CZK 1 billion to eliminate ecological burdens caused by the exploration for and extraction of crude oil and natural gas in the South Moravian Region – Government Resolution No. 777/2019 lowers the limit from CZK 21 billion to CZK 20.970 billion, and
- CZK 1.177 billion to deal with reducing the impacts caused by the termination of coal mining in the Kladno Region – amended by Government Resolution No. 1467/2006 up to CZK 1,427 million and further by Government Resolution No. 688/2008 up to CZK 1,727 million.

In 2010, the Government approved the use of CZK 1 billion of the funds released for the revitalisation of the Moravia and Silesia Region for the financing of environmental actions by the state enterprise, DIAMO. In 2017, the Government approved the amount of CZK 250 million from the same funds for the implementation of measures to prevent the spread of pollution from the old ecological burdens caused by the previous metallurgical activity on the premises of Poldi Kladno Steelworks in mine waters. Thus the programme of revitalisation of the Moravia and Silesia Region and the liquidation of oil-gas wells in the South Moravian Region is not allocated with CZK 21 billion, but only CZK 19.750 billion.

The funds from the proceeds from privatisation are released in accordance with Government decisions to cover the expenses of eliminating environmental damage caused by present operations of mining companies, to cover the expenses of and support investment and non-investment activities connected with the remediation of environmental damage caused by mineral mining and to revitalise affected areas, and for financial support of development projects in areas designated for industrial use approved by the Government.

Dealing with ecological damage created prior to privatisation of brown coal mining companies in the Ústí nad Labem Region and the Karlovy Vary Region

For more than 150 years, the character of the landscape was affected significantly by intensive opencast and underground mining of brown coal in the Krušné Hory Mts. piedmont area of Northwest Bohemia. Underground mining primarily affected the territory with the deepest seams (up to 450 m below the surface) in the central, Most-Bílina area of the basin as well as the Teplice area of the North Bohemian Basin. Opencast mining occurred primarily in areas of coal seam outcrops southwest of Chomutov, west and east of the City of Most, north of the City of Bílina, northwest of the City of Teplice, southwest and north of the City of Ústí nad Labem.

In 2002, the then National Property Fund of the Czech Republic was bound by resolutions of the Czech Republic Government to eliminate ecological damage caused by the activities of coal mining companies in the Ústí nad Labem Region and the Karlovy Vary Region, and to revitalise affected areas. The process was initiated that same year.

In accordance with a relevant resolution of the Czech Republic Government, the process dealing with ecological damage arisen prior to privatisation of brown coal mining companies in the Ústí nad Labem Region and the Karlovy Vary Region includes both of the Krušné hory Mts. Basin situated in the territory of the Districts of Sokolov, Chomutov, Most, Teplice and of Ústí nad Labem, i.e. the Sokolov Basin and the North Bohemian Basin or the mining premises of Sokolovská uhelná, a.s., Severočeské doly, a.s., Mostecká uhelná společnost, a.s. (currently mining companies Severní energetická, a.s. and Vršanská uhelná, a.s.), Kohinoor, a.s., and Palivový kombinát Ústí, s.p.

The programme mentioned specifies a group of projects aimed primarily at creating and renewing:

- forest stands,
- agricultural land,
- bodies of water,
- landscape vegetation,
- biocorridors and biocentres,
- areas for recreation,
- areas designated for ecology and natural science,
- building sites.

As of 31/12/2021, the funds actually spent on **259** finished projects amounted to CZK **12.687 billion** and CZK **0.997 billion** on 22 projects under implementation. The remaining amount required to secure additional money for the projects in progress amounts to CZK **0.208 billion**.

List of companies included in the programme plan:

Sokolovská uhelná, právní nástupce, a.s. (SU)

Severočeské doly a.s. (SD)

Mostecká uhelná společnost, a.s. (MUS) currently mining companies Severní energetická, a.s. and Vršanská uhelná, a.s.

Palivový kombinát Ústí, s.p. (PKÚ) with the registered office in Hrbovice

List of regions (projects of cities and municipalities) included in the programme plan:
Karlovy Vary Region – KK
Ústí nad Labem Region – ÚK

Finished and ongoing projects (in CZK million)

Coal Companies	Finished projects		Ongoing projects		
	Number of projects	Project costs	Number of projects	Project prices	Amount drawn as of 12/31/2021
SU	27	3,228.4	3	4.6	2.7
SD	31	2,218.6	1	12.9	10.3
MUS	58	1,330.1	6	765.5	751.5
PKÚ	45	3,142.2	0	0	0
Total 1	**161**	**9,919.3**	**10**	**783.0**	**764.5**

Municipalities	Finished projects		Ongoing projects		
	Number of projects	Project costs	Number of projects	Project prices	Amount drawn as of 12/31/2021
KK	41	1,268.5	6	195.0	77.6
ÚK	57	1,499.0	6	217.2	145.0
Total 2	98	2,767.5	12	412.2	222.6
Total 1–2	**259**	**12,686.8**	**22**	**1195.2**	**987.1**

Revitalisation of the Moravian-Silesian and South Moravian Region

Currently, the revitalisation of the Moravia and Silesia Region is aimed primarily at eliminating the consequences of ecological burden caused by bituminous coal mining and, in the South Bohemian Region, at eliminating ecological burdens caused by the exploration for and extraction of crude oil and natural gas.

As of 31/12/2021, the funds actually spent on 195 finished projects amount to about CZK **11.831 billion** and on 20 on-going projects the funds amount to about CZK **1.115 billion** as of the specified date.

Categories of priority projects, approved by the Government, which deal with eliminating environmental damage caused by mineral mining in the Moravian-Silesian and South Moravian Region

1. Reclamation work
2. Reducing thermal activity
3. Comprehensive site development
4. Comprehensive reduction of uncontrolled methane emissions
5. Eliminating old ecological burdens in OKD, a.s.
6. Land development upon termination of mining
7. Eliminating ecological burdens caused by the exploration for and extraction of crude oil and natural gas

Finished projects (in CZK) – as of 12/31/2021

Project title	Project costs
1. Reclamation work	
7/02 Reclamation of the Rudná area, Construction No. 5, (along the street Polanecká)	5,213,707
7/03 Reclamation of reservoirs and lands below the Stachanov reservoirs	40,634,358
7/03 Reclamation of reservoirs and lands below the Stachanov reservoirs – additional construction works	8,824,451
7/04 Reclamation of the Žofie waste dump	1,950,601
7/05 Drainage of waterlogged land near Ščučí	7,345,430
7/06 Drainage of lands south of Kuboň Pond – site A and B	2,377,507
7/10 Remediation of the Václav waste dump – external review AR	36,000
7/10 Remediation of the Václav waste dump	18,816,781
7/10 Remediation of Salma	7,105,772
7/14 Reclamation of the Oskar waste dump	6,091,629
7/15 Development along the Orlovská Stream	6,275,508
7/16 Development along the Sušanky Stream	6,796,317
7/16 Development along the Sušanky Stream – phase II.	2,026,032
7/16 Development along the Sušanky Stream – updated estimate of project documentation	17,850
7/17 Remediation of the Urx slide area	6,934,739
Final assessment of the “Reclamation of reservoirs and lands below the Stachanov reservoirs” project – additional construction work	42,000
7/20 Drainage of waterlogged land near Paskov	6,974,421
7/21 Erosion-control measures	821,087
7/18 Capacity increase of the relief channel Ščučí – project documentation	2,134,440
7/23 Reclamation of Lipina area, area A	5,826,744
Total 1	**136,245,375**
2. Reducing thermal activity	
8/01 Survey and monitoring of thermal activity in the Heřmanice waste dump	4,962,696
8/02 Survey and monitoring of thermal activity in the Hedvika waste dump	6,506,627
8/04 Survey and monitoring of thermal activity in the Heřmanice waste dump – site II	4,224,505
8/05 Survey and monitoring of thermal activity in the Ema waste dump	1,487,696
8/10 Comprehensive rehabilitation of the contaminated area in Trojice – stage I: review of risk analyses of the contaminated area	2,337,570
Examiner´s report: Comprehensive rehabilitation of the contaminated area in Trojice – stage I: review of risk analyses of the contaminated area	46,800
8/08 Long term monitoring of thermal activity in the Hedvika waste dump	3,270,345
Total 2	**22,836,239**
3. Comprehensive site development	
9/01 Height measurement in areas with phased out mining operations managed by DIAMO (ODRA) – execution	5,626,650
9/02 Monitoring (incl. measurements) and evaluation of the territory of Slezskoostravský and Bartovický zlom	533,520
Height measurement in areas with phased out mining operations	1,094,800
Examiner´s report: Height measurement in areas with phased out mining operations	44,140
Extinguishing of local fire on the Ludvík waste dump in the cadastral area of Radvanice – project	513,600
Total 3	**7,812,710**
4. Comprehensive reduction of uncontrolled methane emissions	
Comprehensive analysis of the methane problem in connection with old mine workings – study	7,602,000
Examiner´s report on the conceptual solution of the methane problem	35,000

Measures for removal of accidental methane emissions in Orlová	62,873,211
Reducing verified methane emissions in the City of Orlová – Project Orlová 2 – additional construction work	6,933,219
35/1 Security provision of liquidated shaft Jan Maria and remediation of mine area	32,103,924
35/2 Elimination of uncontrolled natural gas emissions from deep exploration boreholes in the area of Trojanovice – survey	19,980,000
35/A Preparing individual methodical procedures of basic activities	1,856,400
Survey of mine gas emissions in areas with phased out coal mining and related health and environmental risks	2,344,300
Reducing verified methane emissions in the City of Orlová – Project Orlová 2	34,503,154
Expert assessment 35/AKT updated project no. 35 – Comprehensive analyses of the methane problem in connection with old mine workings	178,500
35/L1 “Economics of filling underground spaces”	2,261,000
35/L2 Geophysical and borehole survey	1,707,650
35/L3 “Scientific-research support for important safety improvements regarding uncontrolled mine gas emissions from old workings, as a result of dealing with residual coal gas capacity and gas bearing capacity of phased out and abandoned mine sections”	2,261,000
Reducing verified methane emissions in the City of Orlová from 1 February to 31 May 2010 – provision of essential safety measures	2,397,600
Reducing verified methane emissions in the City of Orlová from 1 June to 30 September 2010 – provision of essential safety measures	2,397,600
Reduction of verified methane emissions in Orlová from 1 October 2010 to 31 January 2011 – provision of essential safety measures	2,397,600
Reducing verified methane emissions in the City of Orlová from 1 February 2011 to 31 May 2011 – provision of essential safety measures	2,397,600
Reducing verified methane emissions in the City of Orlová from 1 June 2011 to 30 September 2011 – provision of essential safety measures	2,397,600
Methane emissions in locations of plugged shallow boreholes in the cadastral area of Trojanovice – project	780,000
35/5 Elimination of uncontrolled natural gas emissions from deep exploration boreholes in the area of Trojanovice – boreholes NP 546 and NP 805	48,295,233
35/6 Elimination of uncontrolled natural gas emissions from deep exploration boreholes in the area of Václavovice, Soběšovice, – Dolní Domaslavice, Fryčovice – Příbor východ – exploration	46,607,352
35/D3 monitoring and maintenance of SDD throughout project implementation, control metascreening	21,645,499
35/B OKR area categorisation map	2,264,500
35/D3 Monitoring and maintenance of SDD with continuous data transfers (4 SDD) – project	2,192,121
35/J Reconstruction of the existing Electronic Monitoring System – project	37,815,164
Re-liquidation of SDD Michálkovická jáma	9,389,164
35/7 Liquidation of the oil and natural gas deep exploratory borehole Lm 1 Dolní Lomná	15,471,008
35/4 35/4 – Humanisation of sealed or liquidated old mine works and degassing boreholes in the urban area of Ostrava	192,675,399
35/2 Removal of uncontrolled natural gas outflows from deep exploration wells in the Trojanovice area	105,914,779
Updated project No. 35 – Complex solution of methane problems in connection with old mining works in the Moravia and Silesia Region	1,277,912,021
Ensuring the controlled removal of methane from the underground in the city of Orlová (Project Orlová 3)	111,299,903
Total 4	**2,058,889,201**
5. Eliminating old ecological burdens in OKD, a. s.	
Processing the “Remediation and reclamation of the Kašpárkovice lands” project	809,200
Processing the “Remediation of the Solca tailing ponds” project	1,224,510
Processing the “Development of lands including Karvinský Creek in the area of Špluchov – phase 3” project	1,860,565
Remediation and reclamation of the Křemenec area	113,929,281
Expert assessment of the legitimacy of OKD, a.s. request for approval of Method Changes No. 3 – Křemenec	39,668

Reclamation of waste dump D – reclamation of waste dump D1 and D2	57,387,914
Dolina I land decontamination and reclamation	21,295,875
Louky land reclamation – structure no. 8	60,525,001
Land development within the scope of revitalising the František locality	379,154,077
František locality – additional construction work	63,260,118
Remediation of Solec hill, structure 2 – additional construction work	4,389,633
Remediation of Darkov area, stage I, site C2	386,637,496
Remediation of the former surface mine Paskov	14,020,975
Reclamation of the Lazy waste dump	98,637,394
Remediation of Zdeněk Nejedlý park – phase 1, reclamation of the area southward Karvinský Creek	41,661,196
Remediation at former OKD Doprava, area A – construction work	4,041,581
Remediation of Solec hill, structure 2	10,191,540
Modification of the Stonávka river in kms 0.00 – 2.90, phase A – additional construction work	30,957,408
Reclamation of the D1 waste dump – slope modification	11,432,245
Forensic verification of correctness of the state/OKD ratio (proportion) in financing of submitted sub-projects	0
Reclamation and remediation of the Lazy Mine Sludge Reservoirs I. and II. phase	34,491,794
Modification of the Stonávka river in kms 0.00 – 2.90, phase A	170,899,080
Modification of the river Stonávka in km 0.00 – 2.90 stage A	175,217,948
Total 5	**1,511,173,463**
6. Land development upon termination of mining	
Demolition KOBLOV	6,914,610
Demolition HRUŠOV	6,845,432
Project documentation regarding land development within the scope of eliminating environmental damage upon termination of mining – executed in areas no. 1 and 3 of project no. 45	1,543,500
45/01 František premises, phase 1	13,917,808
45/02 František premises, phase 2 – demolition	1,229,793
Ostravice Dam – Hrabová km 12.05, st. no. 237	63,580,471
Remediation of the damaged Ostravice dam body – additional construction work	12,184,996
45/07 Přívoz premises, demolition	10,835,872
45/08 Pokrok premises, demolition	25,498,110
Slide area stabilisation and drainage modification in the area of Bučinský les in the cadastral area of Radvanice and Bartovice – project	1,591,030
Slide area stabilisation and drainage modification in the area of Bučinský les in the cadastral area of Radvanice and Bartovice – supplemental engineering-geological survey	235,620
45/09 Farma VKK 1 Rychvald premises	19,276,732
VKK Rychvald premises – additional construction work	3,321,357
45/11 Comprehensive development of the water channel and canal network on the premises of the Petr Bezruč mine – project documentation	1,920,000
45/12 Land development upon the termination of mining by DIAMO, s. p., o. z. ODRA – Hlubina premises	7,057,921
45/14 Land development upon the termination of mining by DIAMO, s. p., o. z. ODRA – Barbora premises, 2nd stage	2,268,698
Huminisation of the town centre of Orlová Lutyně – study	2,257,430
Construction of the recreation area "Stříbrné jezero" – project	3,468,000
Reclamation of lands of the former František – Horní Suchá mine – additional construction work	17,729,490
Preparation of a biological assessment according to Act No. 114/1992 Coll., as amended, as part of the land development upon termination of sand and gravel mining – Hlučín	237,600
Realization of Mír Gardens in Svinov – project documentation	201,600
45/15 Petr Bezruč mine premises, phase 2	3,519,308
Reclamation of former mining land in the cadastral area of Malá Štáhle for leisure and tourism purposes – project documentation	2,208,000

Documentation according to article 6, Act No. 100/2001, on environmental impact assessment, noise and dispersion study to the project Huminisation of the town centre of Orlová	228,000
Huminisation of the town centre of Orlová – Lutyně – project documentation	4,447,000
Reclamation of the waterbody in the historic Božena Němcová Park, affected by mining, for leisure activities of residents of the City of Karviná – project documentation	2,352,000
Revitalization of former mining land in the area of the cemetery in Ostrava – Nová Ves	3,591,601
Reclamation of the former sand quarry and forest land in the cadastral area of Sedlnice for leisure activities – project documentation	2,338,350
Revitalisation of former mining land in the cadastral area of Horní Benešov – project documentation	2,358,440
Remediation, reclamation, and revitalization of former gravel-sand-mining areas near Hlučín – project documentation	31,969,683
Reclamation of the centre of the city district Svinov near Bílovecká primary school – project	270,810
Revitalisation of the former mining land in the cadastral area of Bruntál – locality "Za mlékárnou" – EIA documentation	496,100
Remediation and reconstruction of the sewerage system due to residual effects of coal mining in Petřvald	356,308,426
Rehabilitation and reconstruction of the sewerage system due to residual effects of coal mining in Petřvald – additional construction work	13,661,058
Reconstruction of the bridge in Albrechtice – project	1,438,830
Land development upon termination of mining – multifunctional premises of the former Dukla Mine	250,685,969
Revitalization and rehabilitation of areas affected by mining activities in Horní město – village centre revitalization after termination of mining – securing of old stopes	22,741,061
Revitalization and rehabilitation of areas affected by mining activities in Horní město – village centre revitalization after termination of mining – securing of old stopes	1,977,021
Preparation of project documentation and engineering services for the Remediation, reclamation and revitalization of areas near Hlučín upon termination of sand and gravel mining – additional services	3,567,212
Remediation of environmental damage caused by undermining – liquidation of slit tanks – project documentation	1,415,700
Repair of the road along the water conduit to Žermanice dam	2,699,264
Remediation of Slezská Ostrava Castle in connection with damage control of former mining activity and land preparation for leisure activities – DSP	5,838,272
45/20 Potable water conveyance to and from the Alexander premises – project documentation	368,200
Remediation of Mír gardens in Svinov	2,416,799
Revitalization of former mining land in the cadastral area of Bruntál – Locality “Uhlířský vrch” – Stage I – project documentation	145,200
Ostravice river, check dam in the river kilometrage 0.0-3.0 construction No. 5659 – project	2,328,040
Land stabilisation and drainage modification in the area of the Šporovnice locality in the cadastral area of Radvanice – project	1,779,600
45/19 Comprehensive development of the supply of drinking water and its sewage removal on the premises of Koblov – project documentation	2,110,700
Revitalisation of the territory negatively influenced by the construction of water reservoirs for mines and iron works – Revitalisation of the Žermanice dam territory – right bank protection – phase I and II – implementation	70,387,257
Revitalisation and social rehabilitation of lands affected by the mining activity in Horní Město – Skály near Rýmařov – project documentation	1,172,490
Revitalisation and social rehabilitation of lands affected by the mining activity in Horní Město – Rešov Cycle Track – Rešovské vodopády (Rešov waterfalls) – project documentation	965,580
Reclamation of former mining land and rehabilitation of damage arisen by the mining activity in the area of the Hranečník terminal	70,808,037
Remediation of the slope at the Volný Pond in Radvanice	5,626,624
Revitalisation of the territory negatively influenced by the construction of water reservoirs for mines and iron works – Revitalisation of the Žermanice dam – right bank protection – phase I and II – additional construction work	6,819,611
Reclamation of unpaved areas	5,759,645
Reconstruction of a sports complex in Karviná – Ráj – removal of negative impacts of mining activities	60,345,372

Reconstruction of a sports complex in Karviná – Ráj – removal of negative impacts of mining activities – additional construction work	1,496,165
45/24 Liquidation of the major mine works “Obránců míru” and “Úklonné jámy” – additional construction work	886,930
Revitalisation of the centre of the Svinov Municipal District at primary school Bílovická 1 in order to eliminate the negative effects of mining activities from the past – implementation	5,223,969
Reconstruction of the bridge in Albrechtice – implementation	12,418,242
Revitalisation of the area negatively affected by the construction of water reservoirs for the supply of mines and steelworks – Protection of the Těrlická Dam against sewage and reconstruction and extension of water management infrastructure in Třanovice – 1st construction – water supply	8,318,795
Revitalization of the Volný Pond and forest land area in the cadastral area Radvanice for leisure time use	4,798,929
Revitalization of the area after mining activities in the cadastral area Horní Benešov – Cycle paths – project	2,157,330
Revitalization of the area after mining activities in the cadastral area Horní Benešov	9,420,228
Repair of sewer system Heritesova Street (Sewerage Ostrava)	1,192,958
Mitušova Street repair of sewer system (Sewerage Ostrava)	2,821,904
Revitalization (remediation) of the Ostravice river in connection with damage control of former mining activity	171,487,772
Damage control of former mining activity and subsidence of ground – flood control Žabník in Ostrava – Koblová	58,537,837
45/23 Liquidation of mine work “Nová jáma, ZH-jih” – implementation	9,808,875
45/24 Liquidation of the main mine workings “Obránců míru” and “Úklonné jámy” – realisation	43,415,284
45/25 Liquidation of the main mine working “Nová jáma Josef” – realisation	61,707,449
Humanisation of the town centre of Orlová Lutyně – implementation	41,026,416
Odra – remediation of mining impacts – Ostrava Zábřeh, Dubí construction work no. 5039	28,315,097
Elimination of environmental damage caused by undermining – liquidation of slit tanks – realization	11,387,528
Sklářova Street sewer system reconstruction	2,418,660
Harantova Street sewer system reconstruction	4,016,997
Vilová Street sewer system reconstruction	1,213,437
Reconstruction of the road in the center of Karviná as a replacement of the cancelled road in the undermined part of the town	84,417,975
Revitalization of the area after mining activities in the cadastral area Bruntál – Locality „Uhlířský vrch“ – stage I – realization	2,270,479
Olbrachtova Street sewer system reconstruction	3,233,054
Regeneration of the former František – Horní Suchá mine	93,765,102
Revitalization of the area after mining activities in the cadastral district Horní Benešov – Restoration of the traffic road – project	1,010,566
Revitalization of the area after mining activities in cadastral area Bruntál – Locality „Za mlékárnou“ – project documentation	1,149,500
Revitalization of the area after mining activities in cadastral area Bruntál – Locality „Laguny“ – project documentation	1,176,000
Revitalization (rehabilitation) of the surroundings of the Silesian-Ostrava Castle in connection with the removal of the consequences of mining activities from the past and the preparation of the area for leisure activities	32,341,810
Revitalization and resocialization of the area affected by mining activities in Horní Město – Preparation of the industrial zone – project documentation	520,300
Revitalization after mining activities in the cadastral district Horní Benešov – Technical infrastructure in the locality Šibeník	11,961,423
PD Establishment of canal. order in locality Doubrava – border and eng. networks in the locality “U starostky”	1,812,630
PD Sewerage Heřmanice, catchment area Vrbická – Záblatská	23,716
Revitalization of the area after mining activities in the cadastre of Malá Štáhle to a locality for leisure activities and tourism – implementation stage	20,373,236
Extension of the Bruzovice – Za Lipinou water supply system	3,138,065

Revitalization of the center of the village Doubrava – square – project	120,000
Reconstruction of the Mánesova street sewer	4,049,087
Elimination of ecological damage due to mined areas – modification of paved areas in the Municipality of Albrechtice	4,672,965
Revitalization of the territory negatively affected by the construction of water reservoirs for the supply of mines and smelters – Revitalization of the territory of Těrlík water reservoirs – cycle path I. stage – project documentation	438,450
Liquidation of the main mine work 735 – Zálužné 2 collapsing pit and securing of the main mine work 733 – Zálužné Pit in the Nové Těchanovice complex – project documentation	296,450
Reconstruction and extension of collector B to Radvanice (Ostrava sewage system)	66,828,957
Protection of the left bank of the Žermanická Reservoir	39,458,712
Construction of utility networks in the village of Stonava – replacement	30,421,677
Sewerage repair on Budečská Street	4,858,917
Sewerage repair on Hradní Street	5,310,336
Revitalization and resocialization of the area affected by mining activities in Horní Město – Dobřečov – Ferdinadov cycle path – project documentation	851,840
Total 6	**2,045,668,804**
Total 1–6	**5,782,625,791**
7. Eliminating ecological burdens caused by the exploration for and extraction of crude oil and natural gas	
Remediation of old environmental burdens – insufficiently liquidated probes after the extraction of oil and gas – Remediation of the emergency-state probe HR 43	238,144,159
Remediation of old environmental burdens – insufficiently liquidated probes after the extraction of oil and gas – Remediation of the emergency-state probe HR 44 – additional construction work	6,580,424
Remediation of old environmental burdens – insufficiently liquidated probes after the extraction of oil and gas in sector I in the Morava Quaternary Protected Area of Natural Accumulation of Water (PANAW)	750,927,090
Remediation of old environmental burdens – insufficiently liquidated probes after the extraction of oil and gas in sector II in the Morava Quaternary PANAW	639,187,165
Remediation of old environmental burdens – insufficiently liquidated probes after the extraction of oil and gas in sector III in the Morava Quaternary PANAW	461,068,789
Remediation of old ecological burdens – insufficiently liquidated wells after the extraction of oil and gas in sector V in the Morava Quaternary PANAV	365,577,345
Remediation of old environmental burdens – insufficiently liquidated probes after the extraction of oil and gas in sector IV in the Morava Quaternary PANAW	563,317,393
Remediation of old environmental burdens – insufficiently liquidated probes after the extraction of oil and gas in sector VI in the Morava Quaternary PANAW	2,754,045,015
Total 7	**6,048,829,951**
Total 1–7	**11,831,455,742**

Ongoing projects (in CZK)

Project title	Project price	Project costs thus far
1. Reclamation work		
7/09 Reclamation of NP 1 lands	117,400,280	96,805,985
7/12 Land reclamation of Urx dump	4,557,717	3,786,295
Reclamation of Plavicí jáma no. 5/2 area	12,096,935	10,923,525
7/30 Regulation of Zyf brook	3,923,197	3,433,254
Total 1	**138,419,068**	**114,949,059**
2. Reducing thermal activity	**0**	**0**
3. Comprehensive site development	**0**	**0**
4. Comprehensive reduction of uncontrolled methane emissions		
5. Eliminating old ecological burdens in OKD, a. s.		
Decontamination and reclamation of sludge tanks – phase III, IV and V	264,301,317	247,956,039

Total 5	**264,301,317**	**247,956,039**
6. Land development upon termination of mining		
Development of former mining land – Reconstruction of road no.III/472 (Doubrava-Dědina) damaged by mining activities – project documentation	3,071,222	2,572,531
Lučina, revitalization of waterway after mining activity, river kilometrage 0.000-3.262, construction no. 5657 – project documentation	2,747,305	882,450
Remediation of mine damages at Bohumínská Stružka, Rychvaldy weir – Czech Railways track, kms 4.595-10.530, construction no. 5660 – project documentation	2,318,360	0
45/19 Complex solution of drinking water supply and sewerage – realization	41,839,776	41,657,062
Rehabilitation, reclamation and revitalization of the area after gravel mining near Hlučín – implementation	722,410,681	335,506,465
Reconstruction of sewerage at Hrušovská and U Parku streets	47,955,456	10,566,548
Sewerage Heřmanice, catchment area Vrbická – Záblatská	51,982,078	31,487,880
Drainage of the southern part of Svinov	30,647,937	24,307,011
Revitalization of the Těrlická dam and reconstruction of water management infrastructure in the village of Třanovice – 2nd construction – sewage system	122,751,873	73,054,676
Silver Lake Recreation Area – Stage 1 – Implementation	115,603,876	37,525,045
Humanization and revitalization of the Orlová – Lutyně center	242,386,591	57,104,193
Drainage of the village of Doubrava	78,644,196	3,157,773
Revitalization of the territory after the mining activity in the Horní Benešov district – Restoration of traffic communication	68 994 605	21,119,888
Construction modifications MK in the location of the Finnish house	39 648 917	4 008 104
Reconstruction and expansion of the Nová Bělá sewer system – II. Stage, 1st part	51 927 273	13 816 209
77 981 071	0	3 922 561
Revitalization of the Těrlická dam and reconstruction of water management infrastructure in the village of Třanovice – 2nd construction – sewage system	119 462 841	21 135 718
Silver Lake Recreation Area – Stage 1 – Implementation	115 603 876	4 992 033
Humanization and revitalization of the Orlová – Lutyně center	242 386 591	57 104 193
Drainage of the village of Doubrava	78,644,196	3,157,773
Revitalization of the territory after the mining activity in the Horní Benešov district – Restoration of traffic communication	68 994 605	21,119,888
Construction modifications MK in the location of the Finnish house	39 648 917	4 008 104
Reconstruction and expansion of the Nová Bělá sewer system – II. Stage, 1st part	77 981 071	0
Total 6	**1,648,852,438**	**752,143,453**
7. Eliminating ecological burdens caused by the exploration for and extraction of crude oil and natural gas	**0**	**0**
Total 1–7	**2,051,572,823**	**1,115,048,551**

Reducing impacts caused by the termination of coal mining in the Kladno Region

In the middle of 2002, the Czech Republic Government decided to phase out underground mining of bituminous coal in the Kladno Region due to the economic ineffectiveness of mining. This hasty closure of mines in this region brought about, similarly as in the preceding coal districts, the need to deal with eliminating environmental damage caused by past mining operations in a special way.

In consideration of the situation which developed in the Kladno Region, the Czech Republic Government noted the need to reduce the impacts caused by the termination of coal mining in the Kladno Region, by issuing Resolution **No. 552** on 4 June 2003, dealing with the reduction of impacts caused by the termination of coal mining in the Kladno Region. It agreed with the idea of gradually releasing, according to the means of the National Property Fund of the Czech Republic, an amount of up to **CZK 1.177 billion** from FNM resources starting in 2004 in order to deal with ecological impacts caused by coal mining in the past and with land reclamation. Considering the shortage of funds in order to carry out the “Reclamation of the Tuchlovice Mine Waste Dump“ contract, the Czech Republic Government modified the above-mentioned resolution with Resolution **No. 1467** on 20 December 2006, and **agreed** with the idea of gradually releasing, according to the means of the MF, funds in the amount of up to **CZK 1.427 billion** starting in 2004 from a special account managed by the MF pursuant to article 4 of Act No. 178/2005 Coll., on the termination of the National Property Fund, in order to deal with ecological burdens caused in the past and with land reclamation. From that time the sum was increased to **CZK 1.727 billion** pursuant Government Resolution **No. 688** dated 9 June 2008.

The Government of the Czech Republic, by its resolution of 19 April 2017 No. 296, agreed to implement measures to prevent the spread of pollution from the old ecological burdens due to the previous metallurgical activity in the premises of the former steelworks Poldi Kladno into the mine waters, with the approval and inspection processes being implemented within the framework of the programme for mitigating the effects of coal mining in the Kladno Region, which was approved by the Government by Government Resolution No. 552 of 4 June 2003. At the same time, the Government approved the increase of the allocated amount by CZK 250 million from the funds allocated to the revitalisation programme of the Moravia and Silesia Region. Government Resolution No. 777 of 4 November 2019 repealed Government Resolution No. 296 of 19 April 2017, which again increased the limit to CZK 21 billion, but at the same time reduced the limit from CZK 21 billion to CZK 20.970 billion. CZK.

The funds will be used to implement technical solutions to prevent the spread of the old ecological burdens pollution caused by the previous metallurgical activities at the Poldi Kladno premises in mine waters and the possible construction of a mine water treatment plant.

The following projects are considered essential:

- eliminating the dangerous conditions at the V Němcích Schöeller mine waste dump,
- reclamation of the Tuchlovice mine waste dump.

As of 31/12/2021, the funds actually spent on **7** finished projects amounted to **CZK 1.713 billion.**

Finished projects (in CZK)

Project title	Project costs
V Němcích Schoeller mine waste dump – eliminating dangerous conditions	234,429,193
Eliminating the dangerous conditions at the V Němcích Schoeller mine waste dump – stage 2, western section	106,862,466
Eliminating the dangerous conditions at the V Němcích Schoeller mine waste dump – additional construction work	46,608,677
Reclamation of Tuchlovice dump – Supplement no. 1 of the Project Erosion-control measures	20,018,953
Reclamation of the Tuchlovice mine waste dump	1,024,249,827
Reclamation of the Schoeller mine waste dump in Libušín	271,192,891
Reclamation of the Schoeller mine waste dump in Libušín – additional construction work	9,625,428
Total	**1,712,987,435**

GEOLOGY AND MINERALS

Geological evolution of the area of the Czech Republic

Arnošt Dudek

The Czech Republic is located in the very centre of Europe at the limit between the Hercynian Meso-Europe and the Neo-Europe (Fig. 1). There is hardly any country with such a variegated geological structure in such a small area and with such a complex geological evolution. Practically all known rocks and the majority of geological formations and known types of ores and industrial minerals occur on the state territory. Even though most ore deposits are interesting mainly from a scientific and mineral collectors' point of view, a number were of European importance during the Middle Ages and the beginning of modern time. The interesting and complex history of this area attracted attention of researchers already in early times and it strongly influenced the evolution of the mining and geological sciences. It was on this territory where one of the oldest mining laws, the Jihlava Mining Law (1260), and slightly later the mining law of the King Wenceslas II "Ius regale montanorum" (1300), which became basis of many mining laws in other states of the world especially in South America, came into being. The origin of the world-known works of Georgius Agricola, especially his book "Bermannus sive de re metallica dialogus" (1530), is also linked to the territory of the Bohemian Massif.

Three main structural complexes form the geological structure of Czech territory. The oldest one, consolidated already during the Precambrian orogenies, is **Brunia (Brunovistulicum)**, taking basically the area of Moravia. This segment of the Earth's crust probably represents an extremity of the East European platform, even though some researchers consider it as a part of the African plate. The influence of the younger – Paleozoic and Alpine – orogenies was only minor and it served as a foreland of the nappe structures which were thrust over it. The **Hercynian-consolidated Bohemian Massif**, overlapping to the area of the neighbouring Austria, Germany and Poland in the south, west and north, forms the major part of the state territory. Bohemian Massif belongs to the Paleo-Europe. The Hercynian orogeny in the end of the Carboniferous put the finishing touches on it, even though it also contains older building elements. It already behaved as a consolidated block after the Hercynian orogeny, only sometimes flooded by epi-continental sea and affected only by fault tectonics. As a crustal block rising from young sedimentary formations, it broke up only during the younger mountain-building processes, morphologically only in the end of the Neogene and in the Quaternary. Geological continuation of the Hercynides towards the west is indicated by other crustal blocks which were created later – Schwarzwald, Vosges Mountains, the French Massif Central and Iberian Meseta, in the northern branch then the Armorican Massif and massifs in southern England and Ireland. The eastern margin of the Bohemian Massif was thrust over the Cadomian unit of the Brunovistulicum during the Hercynian orogeny. The boundary between the hercynian Mesoeurope and alpine Neoeurope crosses the eastern part of the Czech Republic. The Alpides are represented there by the **West Carpathians**. They are

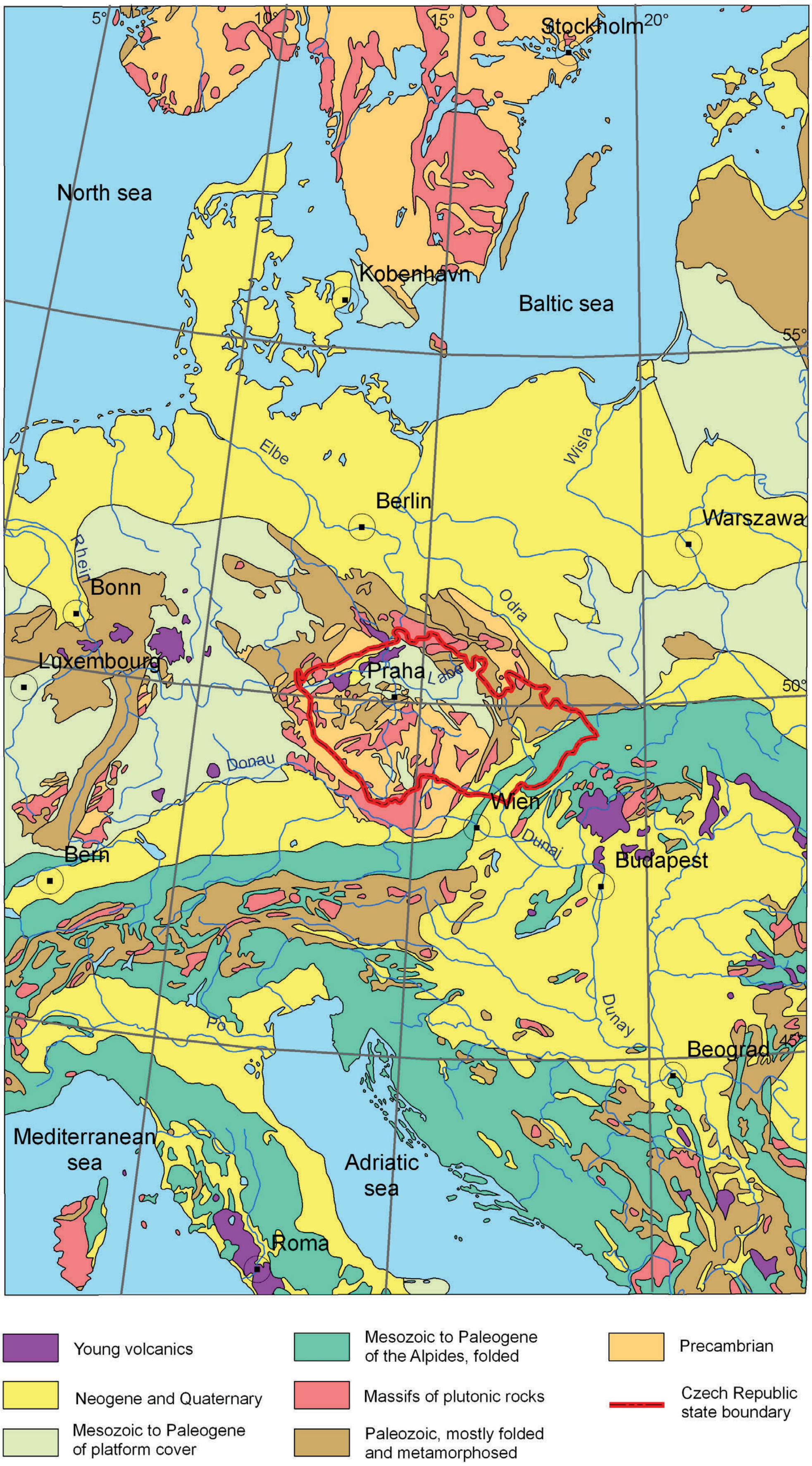


Fig. 1: Geological position of the Czech Republic in Europe

built by an inner unit – Central West Carpathians, Outer Flysh Carpathians and the Carpathian Foredeep. The ***Central West Carpathians*** are formed by pre-Mesozoic volcanosedimentary complexes, mostly metamorphosed and penetrated by late-Hercynian granitoid plutons, and their sedimentary cover (Trias to Lower Cretaceous). At the beginning of Upper Cretaceous the Central Carpathians were intensively folded and in places also metamorphosed. A tectonic zone of first order – the ***Klippen Belt,*** built mostly by Mesozoic sedimentary rocks separates the Central Carpathians from the external Flysh Carpathians. The ***Outer Flysh Carpathians*** are formed (besides rare uppermost Jurassic sediments and local Cretaceous volcanics) predominantly by sedimentary complexes of Cretaceous and Paleogene age. These complexes were as horizontal nappes thrust over the Brunovistulian basement and its sedimentary cover over a distance of tens of kilometres partly even over the Neogene Carpathian Foredeep.

As in the study of the history of mankind, there is little information on the oldest periods of the evolution of the Earth we live on, and our findings are accompanied by a large number of uncertainties. This of course applies also for the Czech territory, even though it belongs to the areas where systematic geological research was in progress since the beginning of the 19th century.

Complexes of the **Brunia (Brunovistulicum)** crop out on the surface only in the western Moravia, but they reach far to the east below the overthrust nappes of the Outer Flysh Carpathians. They are formed by metamorphic rocks – mainly monotonous biotite paragneisses – which were altered during the Proterozoic orogenies, and intruded by huge massifs of abyssal magmatic rocks of about 550 Ma age at the boundary between the Proterozoic and Paleozoic. The Brno and Dyje Massifs represent the exposures of these rocks. Granitoid plutons covering large areas as well as smaller basic massifs of gabbros and norites compacted this unit and prevented its later reworking by younger mountain-building processes, which formed the Bohemian Massif. Western parts of the Brunovistulicum are built by variegated volcano-sedimentary complexes (involving limestones, graphitic rocks, quartzites, amphibolites and orthogneisses). These parts were strongly affected by the Hercynian tectonometamorphic processes. They crop out from beneath of the overthrust Hercynian complexes of the Moldanubicum and Lugicum in tectonic windows of the Dyje and Svratka Domes of the **Moravicum** and Desná Dome of the **Silesicum**. Their appurtenance to the Brunia (Brunovistulicum) has not been commonly accepted yet and these units are by some authors ranked to the Lower Paleozoic and to the Hercynian Bohemian Massif. Platform sediments – the Cambrian conglomerates and sandstones in limited areas, marine Silurian shales sporadically and extensive and important sediments of the Devonian, Mississippian (Lower Carboniferous) and continental sediments of the coal-bearing Pennsylvanian (Upper Carboniferous) – are deposited on the Cadomian basement. The younger platform cover is represented by sediments of the Jurassic, Cretaceous, Paleogene and the Neogene of the Carpathian Foredeep. This consolidated basement was overthrust by nappes of the Outer Flysh Carpathians from the east (Fig. 2).

The lower level (basement) of the **Bohemian Massif** – the epi-Variscan platform – is built by metamorphic rocks intruded by numerous and very large granitoids massifs, and by only weakly metamorphosed or unmetamorphosed but Hercynian-folded Lower Paleozoic. Regionally it is divided (Fig. 3) into the core, formed by the highly metamorphosed **Moldanubicum** and mostly only weakly metamorphosed **Bohemicum (Teplá-Barrandian domain)**. This core is rimmed by the **Saxothuringicum** (Krušné hory Mts.) on the NW, **Lugicum** (Krkonoše Mts., Orlické hory Mts., Králický Sněžník) on the north and **Moravo-Silesicum** (Jeseníky Mts., eastern part of the Českomoravská vrchovina Highlands) on the east (see Fig. 3). These marginal complexes are metamorphosed mostly less intensively than the central Moldanubicum.

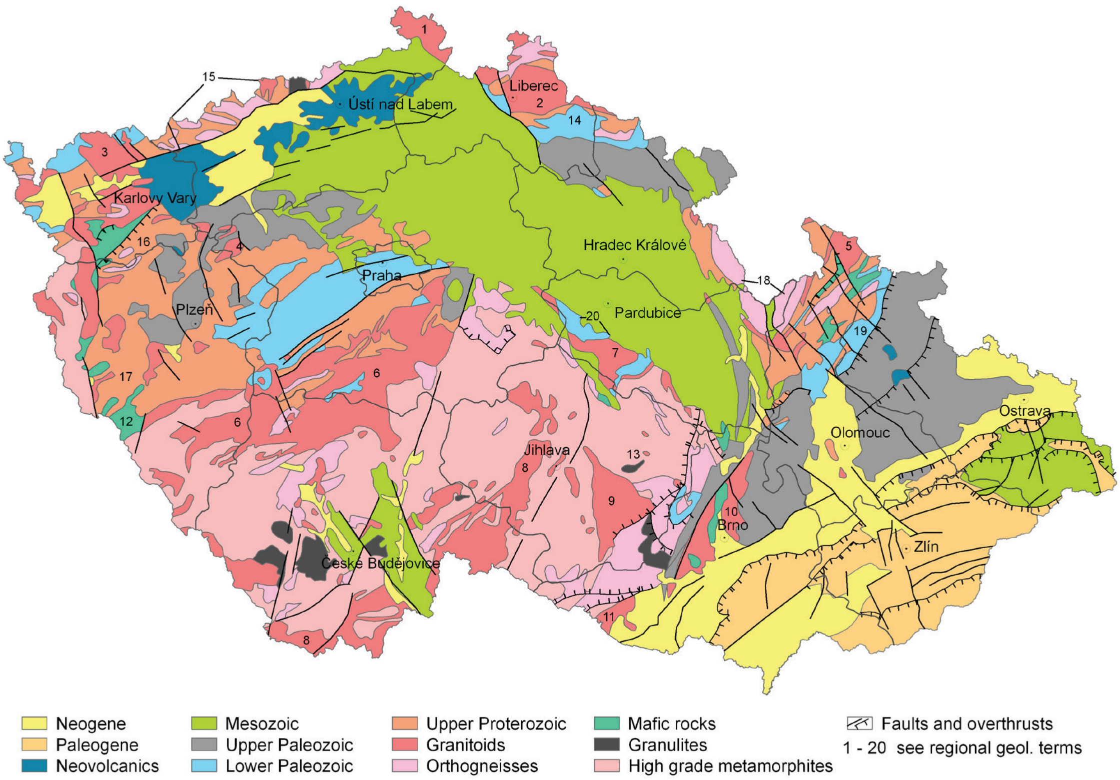


Fig. 2: Geology of the Czech Republic

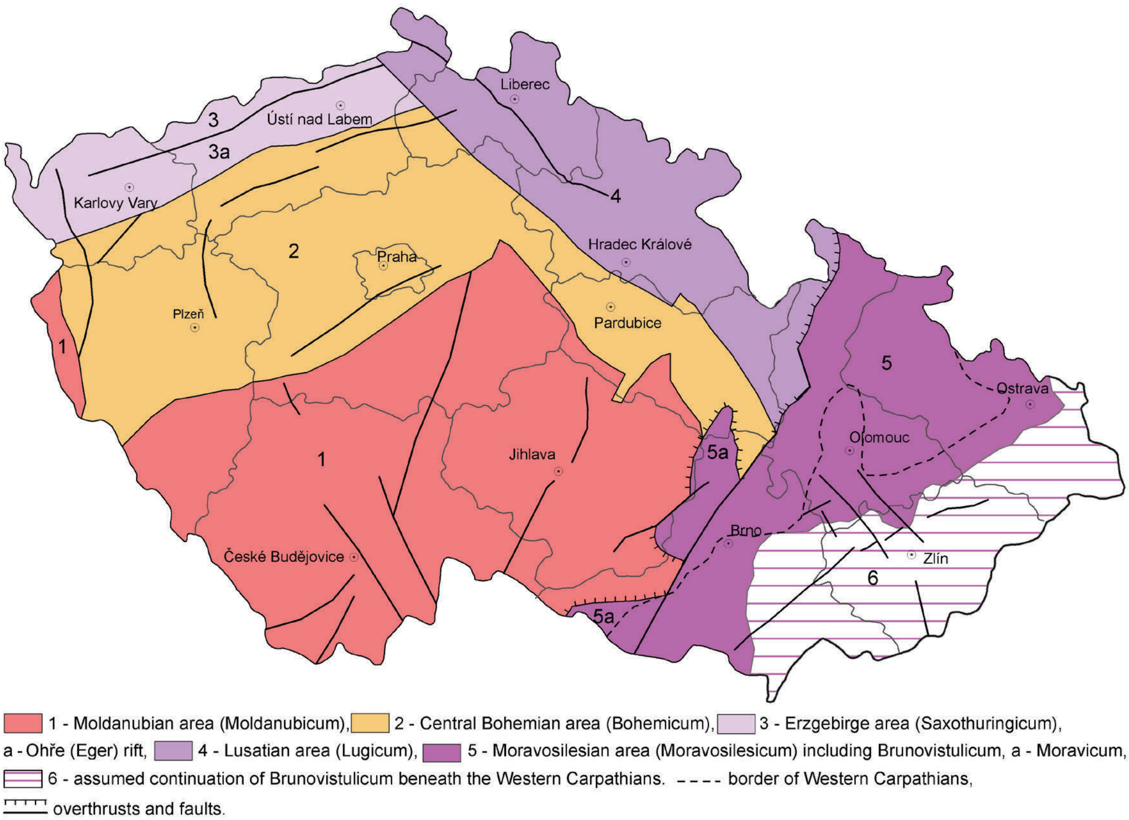


Fig. 3: Regional basement division of the Bohemian Massif on the territory of the Czech Republic

The ***Moldanubicum*** is formed by rocks metamorphosed mainly in the amphibolite facies – sillimanite and cordierite gneisses and migmatites with intercalations of orthogneisses, marbles, quartzites, graphitic rocks and amphibolites. Bodies of high-temperature and high-pressure metamorphic rocks – granulites and garnet peridotites with eclogites – are numerous, too. Their occurrences mark the course of old tectonic zones, along which these rocks were exhumed from depth. They are exposed mainly in southern Bohemia (Blanský les, Prachatice, Křišťanov and Lišov granulite massifs) and western Moravia (Bory and Náměšť granulite massifs). The age of the protolith of Moldanubian complexes is probably Upper Proterozoic; their metamorphism under the amphibolite, granulite and eclogite facies conditions is linked to the Hercynian orogeny. Pre-Paleozoic, Cadomian metamorphism of regional extent, mostly overprinted by the Hercynian processes, is nevertheless documented. Minor bodies of old orthogneisses exhumed along deep-reaching faults in the southern Bohemia, the radiometric age of which is even 2.1 Ga, represent a single exception. They document the existence of the Lower Proterozoic in the deeper crustal structure of the Bohemian Massif. Some Moldanubian rocks, especially gneisses, granulites and amphibolites, represent common resources of building stone.

The metamorphic rock complexes of the central Bohemian ***Bohemicum (Teplá-Barrandian domain)*** as well as the marginal complexes of the Saxothuringicum, Lugicum and Moravo-Silesicum developed by regional metamorphism of mainly Upper Proterozoic protoliths (1,000–545 Ma). During this period, the area of today's Bohemian Massif was covered by a deep sea, in which sandy and clayey rocks were deposited. Surrounding continents, probably rather distant in the mainland formed by very old rocks, represented the source area of the deposited material. Some clastic minerals from metamorphic rocks of the southern Bohemia (up to 2.7 Ga old, in the neighbouring Bavaria even 3.8 Ga) were at least in part derived from the Archaic of the African shield. They were of course deposited much later. The sedimentation was accompanied by submarine volcanism of tholeiitic basalts, which formed linear structures tens of kilometres long, maybe in some cases standing out above the sea level (*island arcs*) as well as much less extensive acid volcanism. The volcanic activity was accompanied by deposition of black shales with abundant pyrite and of siliceous sediments – lydites. Finely banded structures resembling organogenic stromatolites, which would belong to the oldest organic remnants on the Czech territory, were found rarely in the latter. A set of these sediments and volcanic rocks was intensively folded and mostly also metamorphosed in the end of the Proterozoic. Very weakly metamorphosed Proterozoic rocks are nowadays exposed only in central Bohemia between Prague and Plzeň (in the so-called *Barrandian*). The intensity of their alteration increases towards the marginal mountains. A continuous succession of thin metamorphic zones of Barrovian type up to gneisses with kyanite and sillimanite developed especially towards the W and SW. Proterozoic rocks are altered into gneisses and amphibolites also in the Krušné hory Mts., Krkonoše Mts., Orlické hory Mts. and Hrubý Jeseník Mts. These complexes were intruded by numerous massifs of granites (especially Stod, Čistá-Jesenice and Lužice massifs) and gabbros (Kdyně and Poběžovice massifs) in the end of the tectonometamorphic processes especially in the western and northern Bohemia. The Pre-Paleozoic ***Cadomian orogeny*** represents one of the most important magmatogennic and tectonometamorphic processes in the evolution of the Bohemian Massif.

The Earth's crust in Czech territory was not completely solid after the Cadomian orogeny and it gradually broke into a number of smaller blocks, which moved away from each other and were partly flooded by sea again during the ***Lower Paleozoic*** [Cambrian, Ordovician, Silurian, Devonian to Mississippian (Lower Carboniferous)]. Unaltered sediments were preserved especially in central Bohemia, in the area between Prague and Plzeň (Pilsen), named Barrandian, to a lesser extent also in other parts of the Bohemian Massif. In its marginal parts (excluding Brunovistulicum), Paleozoic complexes experienced strong metamorphism and therefore their identification and dating is commonly very difficult. In the Barrandian, sedimentation started already in the ***Lower Cambrian***, represented by a formation of conglomerates and sandstones up to several hundred to thousand meters thick. Sporadic occurrences of shales of fresh-water or brackish origin, in which the oldest fossils of arthropods in Bohemia were found, are known here. Sea penetrated to central Bohemia in the Middle Cambrian and deposited sandstones and especially shales, which are world-known for their occurrences of trilobite fauna. The evolution of the Cambrian was terminated by extensive rhyolites and andesite terrestrial volcanism.

The ***Ordovician*** started by the sea again transgressing in central Bohemia and by the formation of the so-called ***Prague Basin***, the evolution of which continued until the Middle Devonian. The Ordovician rocks are represented mainly by clastic sediments, mostly various types of shales with thick quartzite intercalations), the deposition of which was accompanied by intensive basaltic volcanism. Deposits of sedimentary iron ores (e.g. Nučice, Ejpovice etc.) which were of a high importance in the 19th and beginning of the 20th century originated in relation to the volcanic activity. The Bohemian Massif was located close to the southern polar circle in the Ordovician and sedimentation of rocks as well as volcanic activity proceeded in the sub-polar climate. This crustal segment moved rather rapidly to the north, into warmer waters of the tropic of Capricorn in the end of the Ordovician.

The change of the climate and by this also conditions of development of organisms and sedimentation during the ***Silurian*** resulted in formation of fine-grained black shales with abundant graptolite fauna, accompanied also by intensive volcanic activity and intrusions of numerous diabase sills. Mass development of organisms with carbonate shells occurred in its upper parts with regard to the increasing temperature and massive limestone formations were formed.

Continuous carbonate sedimentation in the Prague Basin lasted until the ***Devonian***, whereas in the surrounding parts of Europe as well as more distant areas the rock deposition was interrupted by the ***Caledonian orogeny***. Gradual unaffected evolution of both the sediments and organisms and their long-lasting detailed study by several generations of Czech paleontologists was a prerequisite for the determination of the first, globally valid ***stratotype*** between two systems (Silurian and Devonian) in Klonk u Suchomast SW of Prague. The limestone sedimentation in the Prague Basin terminated in the Middle Devonian and sandstones with terrestrial flora ended the Devonian sedimentation in this area.

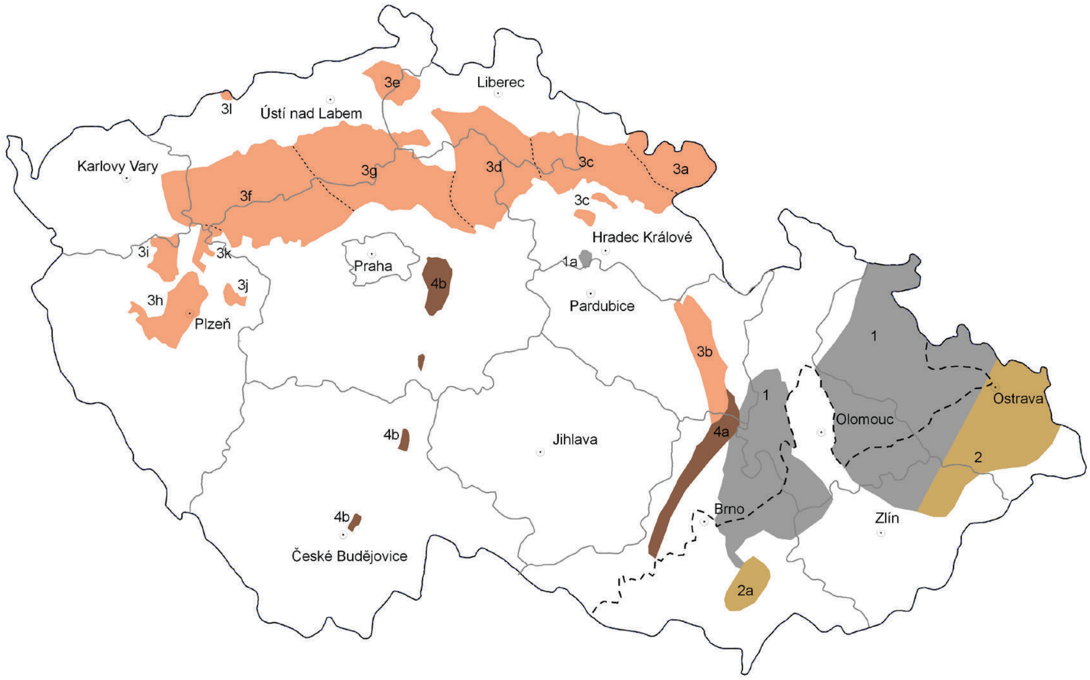
Sedimentation of the Devonian rocks continued in the Upper Devonian only in the area of the Krkonoše Mts. (on Ještěd Mt.) and especially in Moravia in the Jeseníky Mts. and in the Moravian Karst. Evolution of the Devonian in Moravia differed from that on the Bohemian territory. Transgressive complex of the siliciclastic and volcanic rocks with stratiform deposits of Fe, Cu, Au, Zn and Pb overlie the old Brunovistulian basement in its western, more mobile part. This clastic sedimentation continues also in the Mississippian (Lower Carboniferous). The Devonian rocks on the more stable Brunovistulian basement in the south and east begin by clastic rocks, which in places reach over 1,000 m in thickness. Limestones appear only in the Upper Devonian and their evolution continues until the Mississippian (Lower Carboniferous). There is therefore no manifestation that the sedimentation was interrupted by the Hercynian orogeny in Moravia. Sedimentation spaces just moved to the east to Ostrava region and to today's Carpathian basement. Limestones of the Upper Devonian form important deposits especially in central Moravia (e.g. Mokrá, Líšeň, Hranice etc.).

A change in the character of the sedimentation in the end of the Devonian is an expression of the ***Hercynian orogeny***, which affected (about 340–310 Ma ago) the majority of the Czech lands with a high intensity and expressed itself by the development of the nappe structure and a very strong metamorphism of large areas. Even the crystalline complexes formed during the Cadomian orogeny were metamorphosed again. Vast massifs of granitoid magmatic rocks of several thousand km^2 extent, not yet completely uncovered by denudation, formed practically simultaneously. Their intrusions were accompanied also by extensive surface volcanic activity and the development of very numerous deposits of variable genetic types (e.g. Krušné Hory Mts. massifs and Sn, W, Li, Ag, U, Co, Ni mineralization in the Saxothuringicum or Central Bohemian and Moldanubian Plutons in the Moldanubicum and Au, Sb, Ag, Pb, Zn, U mineralization). Granitoid massifs represent an important resource of building and dimension stone as well as feldspar raw materials. Weathered crusts of granitoids (e.g. Krušné hory Mts. massifs, Dyje Massif) are an important source of kaolin, too.

There are two different types of the ***Carboniferous*** and its rocks in the Bohemian Massif as a result of the Hercynian orogeny. The Mississippian (Lower Carboniferous) is represented in Bohemia only by restricted relics of marine sediments found by drillings under the Bohemian Cretaceous Basin E of Hradec Králové, and by weakly metamorphosed slates in the Ještěd Ridge SW of Liberec. The sedimentation of the continental type begins in the intra-mountain basins only in the Pennsylvanian (Upper Carboniferous, Westphalian) and continues in the Permian. Basins with partly individual evolution extend in the Plzeň (Pilsen) surroundings towards the North and Northeast as far as the Broumov area in the NE tip of the Bohemian part of the Czech Republic (Fig. 4), where their stratigraphic extent is the largest and the sedimentation finishes as late as the Lower Triasic. They are to a large extent overlain by sediments of the Bohemian Cretaceous Basin. River and lake deposits – conglomerates, arkoses and shales with layers of tuffs, tuffites and lavas – are in many places accompanied also by formation of coal seams, which were and still are of a high economic importance. Some seams show an elevated U content making them even potential deposits. The Carboniferous arkoses in the Plzeň (Pilsen) and Podbořany regions gave rise to important deposits of kaolin. Carboniferous mainly refractory clay and claystone are important, too. The Bohemian Massif reached the equator on its way to the north and coal formation reflects the dominating tropical climate.

In Moravosilesian area, which was just weakly influenced by the Hercynian orogeny thanks to the solid Brunovistulian basement, the Devonian sedimentation was continuous until the Mississippian (Lower Carboniferous), when the formation of limestones terminated. It was followed by flyshoid sedimentation of conglomerates, greywackes and shales in multiple alternation of individual layers (Culm development). The greywackes represent a resource of a high-quality building stone. The depositional environment gradually changed from marine to fresh-water during the latest Mississippian and the Pennsylvanian (Upper Carboniferous) and important deposits of bituminous coal (paralic basins of the Ostrava, and limnic basins of the Karviná region) formed in the coastal marshes. The Czech part of the Upper Silesian Basin represents the most important bituminous coal mining district in the Czech Republic. The Carboniferous system in the Czech Republic was, and remains, not only an important energy base of the state but also a world-known classical area of Carboniferous flora and fauna.

The Hercynian mountains were rapidly lowered by erosion and denudation in the ***Permian***, and thick formations of red-brown conglomerates, sandstones, arkoses and shales formed.

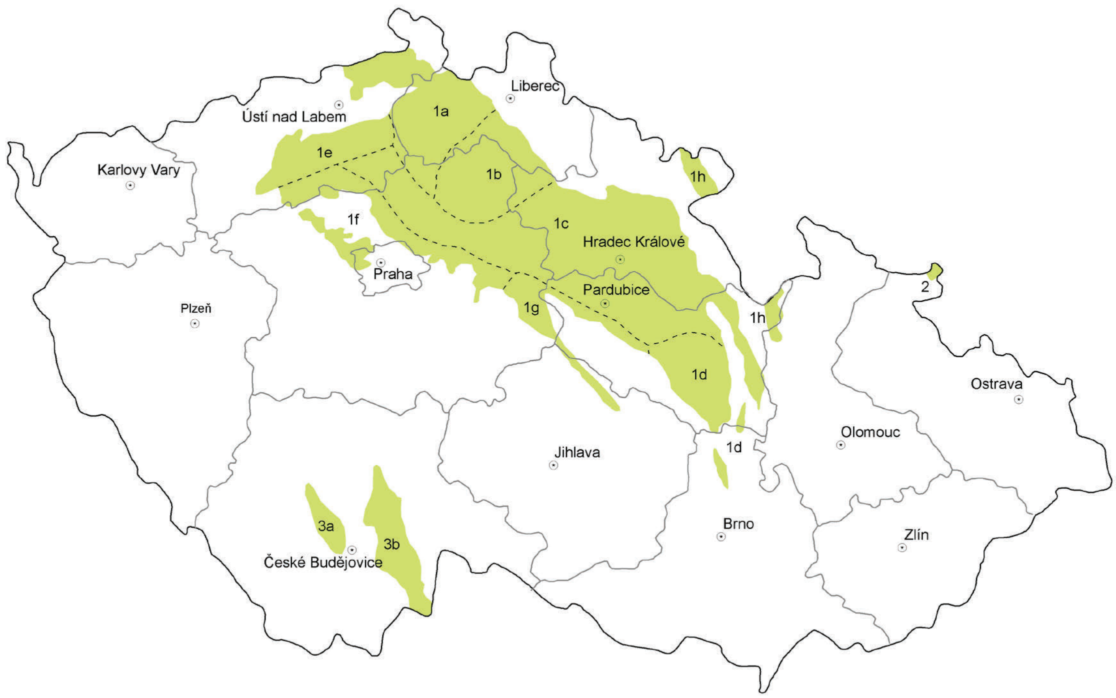


1 - Marine Mississippian (Lower Carboniferous - Culm); a - occurrence near Hradec Králové, 2 - Pennsylvanian (Upper Carboniferous) of the Upper Silesian Basin; a - occurrence in South Moravia, 3 - Limnic Permo - Carboniferous; partial basins: a - Intrasudetic B.; b - Orlice B.; c - Krkonoše Piedmont B.; d - Mnichovo Hradiště B..; e - Česká Kamenice B.; f - Kladno-Rakovník B.; g - Mšeno-Roudnice B. (Mělník B.); h - Plzeň B.; i - Manětín B.; j - Radnice B.; k - Žihle B; l - Brandov occurrence 4 - Permo - Carboniferous of the grabens: a - Boskovice G., b - Blanice G.
--- border of the Western Carpathians, ······· boundary of basins.

Fig. 4: Carboniferous and Permian in the Bohemian Massif and in the basement of the Western Carpathians on the territory of the Czech Republic

Sedimentation was accompanied also by basaltoid, andesitoid up to rhyolitic volcanism of the intra-plate type and sedimentation of clastic rocks with elevated Cu content. A substantial change of climate, caused by the shift of the lithospheric plate with the Bohemian Massif further north, into the belt between the equator and tropic of Cancer, resulted in the formation of deserts, which covered most of Europe. These sediments are today preserved in the Bohemian Massif only in relics. They reach the highest thickness – up to 3 km – in tectonic troughs of roughly N-S direction, so-called grabens (Boskovice and Blanice grabens). Coal seams (today already mined out) of Upper Stephanian age occur locally on the basis of the Permian in these grabens, and higher horizons contain restricted lake and river calcareous sediments. These are commonly overfilled by relics of Stegocephalians and especially of the Permian insects, which made the Boskovice Graben famous.

The Bohemian Massif was slowly uplifted as a compact block after the Hercynian consolidation and it remained mainly land almost until the end of Mesozoic. White lake sandstones of the ***Triassic*** are represented only to minor extent in NE Bohemia in the Krkonoše Mts. Piedmont and Intra-Sudetic Basins. Sea penetrated from the Carpathian area to northern Germany by a narrow channel across northern Bohemia (roughly between Brno and Dresden) in the ***uppermost Jurassic***. This channel linked the deep Tethys on the SE with the shallow shelf sea to the north from the Bohemian Massif. Limestones (Oxfordian–Kimmeridgian) are exposed only in small islands along the Lužice Fault. In the consolidated Bohemian Massif was the ***Alpine orogeny*** represented mainly by origin of faults or rejuvenation of older fault



1. Bohemian Cretaceous Basin and its facies areas (developments): a - Lužice a., b - Jizera a., c - Labe (Elbe) a., d - Orlice-Žďár a., e - Ohře (Eger) a., f - Vltava-Beroun a., g - Kolín a., h - Hejšovina and Bystřice a. 2. Cretaceous in environs of Osoblaha.

3. South Bohemian basins: a - České Budějovice b., b - Třeboň b. ---- boundary of facies areas (developments)

Fig. 5: Upper Cretaceous in the Bohemian Massif on the territory of the Czech Republic

systems. ***Transgression of the Upper Cretaceous sea***, which flooded all the northern and partly also the central part of the Bohemian Massif, was of much higher importance. Several hundreds meters thick strata of the Upper Cretaceous claystones, marlites, sandy marlites and sandstones (the Bohemian Cretaceous Basin – Fig. 5) developed there. The Bohemian Cretaceous Basin is divided into facies areas (developments) shown in Fig. 5 based on character of sedimentation in particular parts of the Basin. Rock complexes of the Basin represent the most important underground water reservoir in the Czech Republic and also an important raw material resource (ceramic and refractory clay, glass, foundry and mortar sand, cement raw materials, building and sculpture stone but also uranium). A small occurrence of Upper Cretaceous sediments near Osoblaha is an extremity of the Polish Opole Cretaceous Basin. Smaller, but fresh-water Upper Cretaceous basins formed also in southern Bohemia. It is the České Budějovice Basin localized more westward and the Třeboň Basin localized more eastward.

The evolution in Moravia was different. The Triassic is not represented at all, whereas in the ***Jurassic*** the sea penetrated from the Mediterranean area far to the NW and flooded the eastern margin of the Bohemian Massif. Jurassic sediments are nowadays to a large extent covered by rocks of the Neogene or the Outer Flysh Carpathian nappes. Tectonic blocks of the Jurassic limestones, exhumed from depth in front of the Carpathian nappes and forming isolated klippen by Štramberk and in the Pavlovské vrchy Hills, represent an important land-forming element and also an important resource of very pure carbonate raw material.

The character of the sedimentation in the Outer Carpathians markedly changed in the ***Cretaceous***. Sediments formed in deeper sea from submarine slides and turbidite currents,

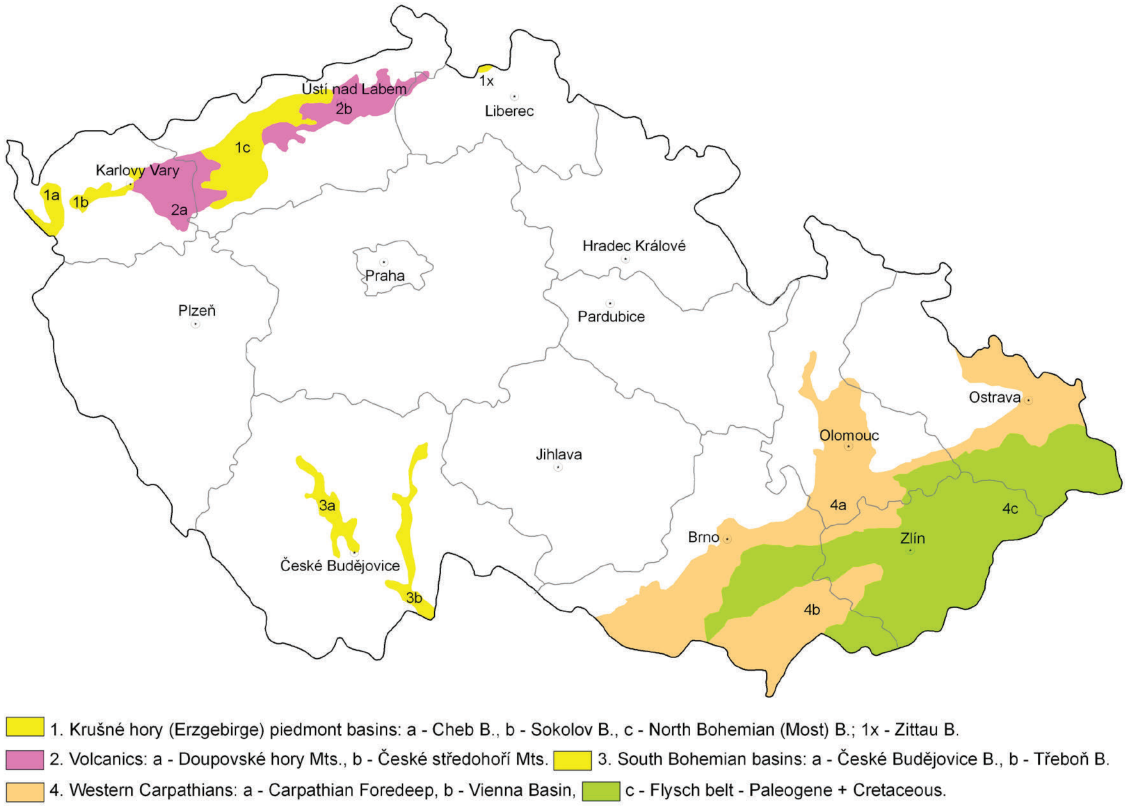


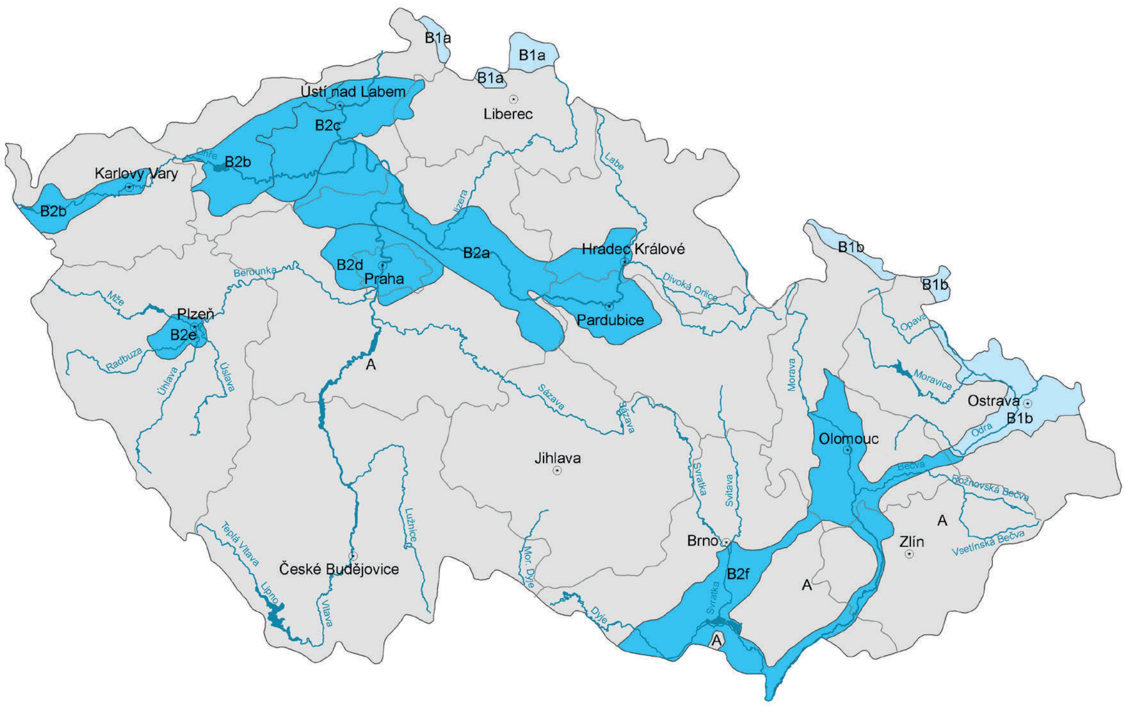
Fig. 6: Tertiary in the Bohemian Massif and Western Carpathians on the territory of the Czech Republic

transporting clastic material far from the land. They are characterized by multiple alternations of sandy and clayey layers of a low thickness (dm to m) and infrequently also sandstone benches, which are collectively called **flysh**. The sediments reach even many thousand meters in thickness. The flysh sedimentation continued in this area also in the Paleogene (Fig. 6).

The Bohemian Massif remained land which was only occasionally flooded in the east by shallow epicontinental sea from the Carpathian area. Nevertheless, several depressions with intensive freshwater sedimentation were formed as a result of strong tectonic movements in the Alpine and Carpathian space in the end of the ***Paleogene and in the Neogene***. This is the area of the South Bohemian basins (the České Budějovice Basin and the Třeboň Basin) with lignite, clay and diatomite deposits and also a marked tectonic trough of the SSW-NNE direction (Ohře Rift) in north-western Bohemia, where the Krušné Hory Piedmont basins (Cheb, Sokolov, North Bohemian and Zittau) formed – see Fig. 6. Sandstones and especially clays and claystones with thick (exceptionally and locally up to 60 m) brown coal seams sedimented in these basins. Brown coal deposits in the North Bohemian and Sokolov basins represent the most important brown coal deposits in the Czech Republic. Important deposits of Neogene clays then occur in the Cheb Basin. Formation of basins was accompanied by very intensive **volcanic activity** and a large accumulation of lavas and pyroclastics (the Doupovské hory Mts. Volcanic Complex, České středohoří). The rocks are mainly various types of olivine basalts and alkaline basaltic rocks, to lesser extent also more acid phonolites. Volcanic conduits and necks give today's landscape a beautiful character. The main volcanic activity took place 35–17 Ma ago, a younger phase 8 Ma ago and the last minor volcanoes are just several thousand years old (Komorní and Železná hůrka). The area represents a classical example of alkaline volcanism and it played an important role in the evolution of geosciences. The rocks are important not only as a building stone but also as a raw material for manufacture of molten basalt products. Deposits of the Bohemian garnets at the southern margin of České středohoří are related to the volcanic activity, too (pyropes were carried up by volcanic necks from the ultrabasic rocks in the crystalline basement). Weathering and decomposition of tuffs of the Doupovské hory and České středohoří Mts. resulted in the formation of important bentonite deposits.

The flysh complexes of the Carpathian area were folded and thrust in the form of nappes (verified by exploration) over a distance of several tens of kilometres towards the west and southwest over the Bohemian Massif in the end of the ***Paleogene***. The Carpathian Foredeep, partly still covered by the arriving nappes, formed in front of the thrust nappes in the ***Neogene*** (Miocene). The sediments of the Vienna Basin (of up to 5 km in thickness) were subsequently hardly folded. These are represented mainly by marine clay, marl and sand, just partially diagenetically consolidated, which contain smaller deposits of oil and gas. The depositional setting of the younger formations became progressively fresh-water. The youngest ones contain deposits of lignite.

Important tectonic processes expressing themselves by marked vertical movements of individual crustal segments operated in the Bohemian Massif in the end of the Tertiary and beginning of the Quaternary. In this way, the marginal mountains – Šumava Mts., Český les Mts., Krušné hory Mts., Krkonoše Mts., Orlické hory Mts. as well as Hrubý Jeseník Mts. – were uplifted by up to 1,000 m and the Bohemian basin was formed. This is sometimes considered



A - Quaternary of the denudation areas, B1 - Quaternary areas of the continental glaciation: a - North Bohemian Area, b - North Moravian Area, B2 - Quaternary of the extra glacial areas: a - Labe (Elbe) a., b - Krušné hory (Erzgebirge) piedmont basins, c - České středohoří Mts., d - Praha Plain, e - Plzeň Basin, f - Moravian dales.

Fig. 7: Quaternary division on the territory of the Czech Republic

as being formed by the impact of a large meteorite, but this is a nonsense resulting from the interpretation of satellite images without knowledge of the real structure of the massif. The Bohemian Massif was influenced by several phases of continental and mountain **glaciations** during the ***Quaternary***. A periglacial climate dominated here, which resulted in the formation of massive stony debris and block-seas, terrace system of the rivers (Fig. 7) as well as really extensive loesses. Terrace sediments of rivers especially form important deposits of sand and gravel and feldspar raw materials, and loesses of brick clays. The continental ice sheet reached as far as the northern margin of the massif and left sediments of frontal moraines in the Ostrava region, on the northern piedmont of the Hrubý Jeseník Mts. and in the Šluknov and Frýdlant extremities. Mountain glaciers modified morphology of the marginal mountains, especially the Krkonoše Mts., to a lesser extent also the Jeseníky Mts. and Šumava Mts., where even minor glacier lakes formed.

Figures in this chapter were adapted by the author from

Dudek, A., Svoboda, J. (1968): Geological position of Czechoslovakia in Europe. – IGC Praha;

Geologie České republiky, postcard – ČGÚ [Geology of the Czech Republic, postcard. – Czech Geological Institute.];

Mísař, Z., Dudek, A., Havlena, V., Weiss, J. (1983): Geologie ČSSR. I. Český masiv. – SPN Praha [Geology of the Czechoslovak Socialist Republic. I. Bohemian Massif. – State Pedagogic Publishing House];

Zpráva Československé stratigrafické komise (1992): Regionálně geologické dělení Českého masivu na území České republiky. – Časopis min. geol., 37, 257–276, Praha [Report of the Czech Stratigraphic Commission (1992): Areal geological division of the Bohemian Massif on the territory of the Czech Republic. – Journal for Mineralogy and geology, No. 37, pp. 257–276, Praha]

Regional geological units and minerals associated with them

(that minerals are indicated whose deposits belong to the units; digits of figures and units are related to the previous chapter "Geological evolution of the area of the Czech Republic")

Arnošt Dudek

Bíteš orthogneiss – mostly muscovite orthogneiss of the Cadomian age, characteristic of the Moravicum of the Dyje and Svratka domes between Krems in Austria and Svojanov in the Czech Republic (opal, kaolin, crushed stone) – Fig. 3 – unit 5a

Blanice Graben – fault system of the NNE-SSW direction in central and southern Bohemia, marked also by downthrown islands of the uppermost Carboniferous and Permian with hard coal and anthracite seams. It continues as Rodel line in Austria (Au-Ag-ores) – Fig. 4 – unit 4b

Bohemian Cretaceous Basin **–** sediments of the Upper Cretaceous (Cenomanian to Santonian), overlying mainly crystalline complexes and Upper Paleozoic rocks in the northern part of the Bohemian Massif. Based on the lithological character, it has been regionally classified into facial developments as follows:

- *Lužice* (U-Zr-ores, glass and foundry sand) – Fig. 5 – unit 1a
- *Jizera* (glass and foundry sand, dimension stone) – Fig. 5 – unit 1b
- *Orlice-Žďár* (foundry sand) and its *east Bohemian* (clays) and *Moravian parts* (clay) Fig. 5 – unit 1d
- *Ohře (Eger)* – the Most, Teplice (quartzite, corrective additives for cement production) and Louny part (clay) Fig. 5 – unit 1e
- *Vltava-Beroun* including Prague surroundings (clay, dimension stone) Fig. 5 – unit 1f

Boskovice Graben – tectonic trench of the NNE-SSW direction in western Moravia filled with sediments of the uppermost Carboniferous and Permian (hard coal) Fig. 4 – unit 4a

Bory granulite massif – a small granulite body in the Moldanubicum N of Velké Meziříčí in western Moravia (feldspar, crushed stone) – Fig. 4 – unit 4a

Brno Massif **–** a large massif in western Moravia built by a variable series of both acid and basic plutonic rocks of the Cadomian age (feldspar, crushed stone) – Fig. 2 – unit 10

Carpathian Flysh **–** a part of the Outer Carpathians in eastern Moravia built by clayey and sandy Cretaceous and Paleogene sediments, with a marked nappe structure of the pre-Miocene age. It composes the Chřiby Mts. and the Ždánice Forest and mountain ranges on the border with Slovakia – the Beskydy, Javorníky and Bílé Karpaty Mts. (natural gas) – Fig. 6 – unit 4c

Carpathian Foredeep – the external part of the Carpathian mountain chain in eastern Moravia, which was formed in front of the Outer Carpathian nappes and overlies the south-eastern slope of the Bohemian Massif. It is filled with the Miocene sediments of the Egerian to Badenian (oil, natural gas, clay, bentonite, gypsum in the Opava Basin) – Fig. 6 – unit 4a

Central Bohemian Pluton – an extensive Hercynian granitoids pluton on the border between Bohemicum and Moldanubicum, more basic than the massifs of the Krušné hory Mts. and in Českomoravská vrchovina Highlands (granodiorites, tonalite, diorite). Important deposits in the exocontact (U, Au, Ag-Pb-Zn-ores, feldspar, quartz, dimension and building stone) – Fig. 2 – unit 6

Cheb Basin – the westernmost of the Tertiary basins, at the crossing of the Ohře rift and the Tachov Graben. Sedimentation continued from Eocene until Pliocene (brown coal, kaolin, clay, diatomite, glass and foundry sand – numerous conflicts of interest) – Fig. 6 – unit 1a

České Budějovice Basin – a smaller, western basin of South Bohemian basins, filled with fresh-water sediments of the Upper Cretaceous and to a minor extent Neogene and Quaternary. Episodic ingressions of the sea from the Alpine foredeep (lignite, tectites, diatomite, sand and gravel) – Fig. 6 – unit 3a

České středohoří Mts. – a classical area of the Tertiary alkaline volcanic rocks (olivine basalts to phonolites) exposed in the Ohře (Eger) rift between Chomutov and Nový Bor, with the main volcanic centre in Roztoky nad Labem (pyrope, diatomite, feldspar substitutes, crushed stone) – Fig. 6 – unit 2b

Čistá-Jesenice Massif – a minor granitoid massif in western Bohemia composed of both Cadomian and Hercynian bodies. It is covered from a large part by Carboniferous and Permian sediments (feldspar, dimension and building stone) – Fig. 2 – unit 4

Domažlice Crystalline Complex – south-western part of the upper Proterozoic of the Bohemicum in the Šumava piedmont, metamorphosed during both Cadomian and Hercynian orogeny, with minor massifs of granitoids and gabbroic rocks and abundant pegmatites (feldspar) – Fig. 2 – unit 17

Doupovské Hory Mts. – a volcanic complex of the Tertiary age at the crossing of the Ohře rift with the Jáchymov fault, between Karlovy Vary and Kadaň. Alkaline volcanic rocks are represented mainly by olivine basalt, "leucitic" tephrite and abundant tuffs. Phonolites are missing (bentonite, crushed stone) – Fig. 6 – unit 2a

Dyje Massif – a massif of the Cadomian granitoids in the Dyje Dome of the Moravicum in SW Moravia, extending from the northern vicinity of Znojmo almost to Danube. It was affected by a strong tropical weathering in the Jurassic and Neogene and from a large part covered by sediments of the Carpathian foredeep (kaolin, feldspar, building stone) – Fig. 2 – unit 11

Hroznětín Basin – the northern extremity of the Sokolov Basin N of Karlovy Vary (bentonite) – Fig. 6 – unit 1b

Intra-Sudetic Basin – southern extremity of the Lower Silesian Basin in the NE tip of Bohemia, with sedimentary fill from the Mississippian (Lower Carboniferous) to Upper Cretaceous about 3,000 meters in thicknes, and Pennsylvanian and Permian volcanites. (hard coal) – Fig. 4 – unit 3a

Islet zone of the Central Bohemian Pluton – a number of both large and minor blocks of the contact metamorphosed Proterozoic and Lower Paleozoic rocks from the mantle of the pluton, downthrown into granitoids (Au, building stone, barite, limestone) – Fig. 2 – unit 6

Jílové Belt – a belt of the Upper Proterozoic volcanic (basalt, andesite, boninite and rhyolites), subvolcanic and acid plutonic rocks extending over 120 km in NNE-SSW direction south of Prague, from a major part enclosed in granitoids of the Central Bohemian Pluton (Au-ores, building stone) – Fig. 2 – unit 6

Kdyně Massif – a complex of metabasic, gabbroic and dioritic rocks in the Domažlice Crystalline Complex on the border of Šumava and Bohemian Forest (dimension and building stone) – Fig. 2 – unit 12

Kladno-Rakovník Basin – one of the basins of the Central Bohemian limnic Carboniferous, partly covered by Cretaceous sediments (hard coal, kaolin, claystone) – Fig. 2 – unit 12

Krkonoše-Jizera Crystalline Complex – western part of the Lužice area built by metamorphic rocks of the Proterozoic and Lower Paleozoic age (limestone, dolomite) and intruded by plutons of the Cadomian (Lužice) and Hercynian (Krkonoše-Jizera) age (feldspar, dimension and building stone). Fe-bearing skarns, Sn and W-ores, fluorite and barite occur in the exocontact of the plutons – Fig. 2 – unit 14

Krkonoše-Jizera Massif – Hercynian granitoid massif building the border range with Poland (excellent dimension stone, feldspar) – Fig. 2 – unit 2

Krkonoše Mts. piedmont basin – one of the Sudetic (Lugian) Upper Paleozoic basins partially covered with Cretaceous sediments. Formations encompass Westphalian C, Stephanian, whole Permian and extend up to the lowermost Triasic (Cu-ores, Au paleoplacers, bituminous coal, pyrope) – Fig. 4 – unit 3c

Krušné hory Mts. Piedmont basins – a group of limnic Tertiary basins associated with the Ohře Rift SE of the Krušné hory Mts. From WSW to ESE, these are: Cheb, Sokolov and North Bohemian basins. – Fig. 6 – unit 1

Krušné hory Mts. Pluton – a large Hercynian granitoid pluton underlying metamorphic rocks of the Krušné Hory and Smrčiny Mts., exposed by erosion only in numerous partial massifs (Sn-W-ores, Li-Rb-Cs ores, kaolin, feldspar, quartz, building stone) – Fig. 2 – unit 3

Krušné hory Mts. Crystalline Complex – a part of the Saxothuringicum built by metamorphic complexes mostly of the Proterozoic, subordinately also of the Lower Paleozoic age (U, Ag, Bi, Co, As-ores, Cu-ores, Sn-skarns, fluorite, barite, kaolin) and intruded by Hercynian granitoids. – Fig. 3 – unit 3 (Fig. 2 – unit 15)

Lužice Massif – an extensive Cadomian granitoids massif predominantly on the German territory, extending into the Jizera Mts. (quartz, dimension and building stone) – Fig. 2 – unit 1

Moldanubian Pluton – the largest Hercynian granitoids complex in the Bohemian Massif in Českomoravská vrchovina Highlands, Šumava and Waldviertel (dimension and building stone; Au-W and U-ores and Ag-Pb-Zn-ores in the exocontact) – Fig. 2 – unit 8

Moldanubicum – basement of the southern part of the Bohemian Massif built by high-grade metamorphic complexes of Proterozoic and probably also Lower Paleozoic age. The cadomian tectonometamorphic processes were followed by hercynian high temperature and low pressure metamorphism and the whole complex was penetrated by numerous late-Hercynian granitoid plutons. – Fig. 3 – unit 1

Moravian-Silesian Devonian – weakly metamorphosed volcano-sedimentary unites in the Jeseníky Mts. – *Vrbno Strata, Šternberk-Benešov Belt* (Fe-ores, Cu-ores, Pb-Zn-ores, barite, quartzite, dolomite) – Fig. 2 – unit 19

Moravian-Silesian Carboniferous – marine flyshoid Mississippian (Lower Carboniferous) of the Nízký Jeseník Mts. and Drahany Highlands (slate, quartz) and productive paralic Mississippian to limnic Pennsylvanian (Upper Carboniferous) of the Ostrava region (Upper Silesian Basin – hard coal, natural gas) – Fig. 4 – unit 1, 2

Mšeno-Roudnice Basin – one of the Central Bohemian Carboniferous to Permian basins, completely overlain by the Bohemian Cretaceous Basin (hard coal) – Fig. 4 – unit 3g

Nasavrky Massif – a minor however very complex Hercynian granitoid body exposed in the Železné hory Mts. (pyrite, dimension and building stone; fluorite and barite in the exocontact) – Fig. 2 – unit 7

North Bohemian Basin – the largest Tertiary basin of the Ohře Rift between the Doupov Mts. and České středohoří Mts. (brown coal, clay, bentonite, diatomite, quartzite) – Fig. 6 – unit 1c

Ohře rift **–** a prominent fault structure in the south-eastern piedmont of the Krušné hory Mts. delimited by the Krušné hory and Litoměřice faults and their directional continuations. Tertiary alkaline volcanites, coal-bearing basins and mineral as well as thermal waters are associated with the rift – Fig. 3 – unit 3a

Orlické hory Mts.-Kłodzko Crystalline Complex **–** metamorphic complexes of probably Proterozoic age in the eastern part of the Lužice area in the Orlické hory and Rychleby Mts. and in Kłodzko – Fig. 2 – unit 18

Outer klippen zone of the Western Carpathians **–** extensive fragments of Jurassic and Cretaceous sediments brought up from depth in front of the flysh nappes – Štramberk, Pavlovské vrchy (limestone) – Fig. 2 and 6 – unit 4c

Plzeň Basin **–** an independent basin at the SW margin of the West Bohemian Carboniferous (hard coal, kaolin, clay) **–** Fig. 4 **–** unit 3a

Quaternary alluvia – alluvia and terraces of majority of larger water courses (feldspar, sand and gravel, in south Bohemia and SW Moravia also tectites) **–** Fig. 7 **–** units B2a, B2b, B2f

Quaternary placers – in piedmont of the Šumava and Jeseníky Mts. (Au), Krušné Hory Mts. (Sn), southern piedmont of the České středohoří Mts. (pyrope)

Sokolov Basin – the smallest Tertiary basin of the Ohře Rift WSW of the Doupovské hory Mts. with important deposits of energy minerals (brown coal, U, clay, bentonite) – Fig. 6 – unit 1b

South Bohemian Basins – freshwater sedimentation space of the Upper Cretaceous and Tertiary age, where the Rudolfov horst separates the smaller České Budějovice Basin in the west from the larger Třeboň Basin in the east – Fig. 6 – unit 3

Svratka Dome of the Moravicum – the northern of the domes built by metamorphic rocks of the Moravicum W of Brno (graphite, feldspar, limestone, building stone) – Fig. 3 – unit 5a

Syrovice-Ivaň terrace **–** a higher located Quaternary terrace between the Jihlava and Svratka rivers S of Brno (feldspar) – Fig. 7 – unit B2f

Teplá Crystalline Complex – the NW part of the Proterozoic of the Central Bohemian area (Bohemicum) with a rapid succession of metamorphic zones from SE to NW into the Slavkov Forest (feldspar) – Fig. 2 – unit 16

Tertiary relics of the Plzeň region **–** relics of the formerly more extensive Tertiary sediments on the site of a river paleostream discharging into the North Bohemian Basin (clay, bentonite) – not shown on scale of the maps

Třebíč Massif **–** an extensive massif of the Hercynian melanocratic granitoids and syenitoids (durbachites) in the Českomoravská vrchovina Highlands (amethyst, morion, feldspar, dimension stone) – Fig. 2 – unit 9

Třeboň Basin – a larger, eastern basin of South Bohemian basins with continental Cretaceous and Tertiary sediments (kaolin, clay, bentonite, diatomite) **–** Fig. 6 **–** unit 3b

Upper Silesian Basin – a Carboniferous basin formed by sediments of Upper Mississippian and Pennsylvanian situated predominantly in Poland and extending to the Czech Republic only by its SW part. It is formed by volcanoclastic sediments with numerous hard coal seams. On the Czech territory, it is further subdivided into i) western, more mobile paralic Ostrava part, ii) eastern, platform limnic Karviná part and iii) southern Beskydy part (hard coal, natural gas) **–** Fig. 4 **–** unit 2

Variegated Group of the Moldanubicum **–** metamorphic complexes of paragneisses and migmatites with numerous intercalations of amphibolites, marbles, quartzites, graphitic rocks and skarns (Fe-skarns, graphite, feldspar, limestone, dolomite, fluorite, building stone) – part of the Modanubian unit 1, in Fig. 3

Vienna Basin – an extensive Tertiary Neogene basin with marine sedimentary fill gradually becoming freshwater of more than 5,000 m in thickness (lignite, oil, natural gas) – Fig. 6 – unit 4b

Železné hory Mts. area – part of Bohemicum built by weakly metamorphosed volcano-sedimentary series of the Upper Proterozoic and sediments of the Lower Paleozoic (Mn-Fe-carbonates, pyrite, fluorite, barite, limestone) and the Hercynian granitoid Nasavrky Massif – Fig. 2 – unit 20

Zittau Basin – a Tertiary basin in the continuation of the Ohře Rift, extending only by a negligible south-eastern extremity into the Czech territory (brown coal, lignite, clay) – Fig. 6 – unit 1d

Žulová Massif – a minor Hercynian granitoid massif in the northern tip of the Moravian-Silesian area (kaolin, quartz, dimension and building stone) – Fig. 2 – unit 5

Geodynamics of the origin of the Bohemian Massif covering the territory of the Czech Republic

Karel Schulmann, Vojtěch Janoušek, Ondrej Lexa

The Bohemian Massif represents one of the largest exposure of the European Variscan belt located at its eastern extremity (Figure 1). The Variscan architecture of the Bohemian Massif can be defined by four major tectonic units: 1) The Saxothuringian Neoproterozoic continental basement with its Palaeozoic cover, 2) The Teplá-Barrandian (Bohemicum) Neoproterozoic basement and its Early Palaeozoic cover of the Prague Basin (the Bohemia Terrane of South Armorica), 3) The Moldanubian high- to medium-grade metamorphic unit intruded by numerous Carboniferous granitic plutons, altogether forming the high-grade core of the orogen, 4) The easterly Brunia Neo-Proterozoic basement with Early to Late Palaeozoic cover.

The Gondwana faunas of Lower Palaeozoic (Cambrian and Ordovician) sediments of the Saxothuringian and Teplá-Barrandian domains and numerous isotopic and U-Pb zircon data imply affinity to northern Gondwana margin. Schulmann et al. (2009) suggested that the Variscan structure of the Bohemian Massif resulted from Andean type convergence and formed as a typical upper plate orogen located above a long lasting Devonian-Carboniferous subduction system. These authors shown that all the current criteria defining an Andean type of convergent margin are present and surprisingly well preserved. In particular it is: 1) the development of blueschist facies metamorphism along the Saxothuringian margin, 2) calc-alkaline to potassium rich (shoshonitic) arc type magmatism in distance 150–200 km from the suture zone (Žák et al., 2005), 3) back-arc basin developed on continental upper plate crust later replaced by thick continental root (Schulmann et al., 2005), 4) deep granulite facies metamorphism associated with supposed underplating of the crust by mafic magmas at the bottom of the root and 5) continental lithosphere underthrust underneath the thickened root system. Based on these criteria, the architecture of the eastern Variscan belt is interpreted as the result of a large-scale and long-lasting subduction process associated with crustal tectonics, metamorphism, magmatic and sedimentary additions that developed over the width of at least 500 km, in present coordinates, and time scale of ~80 Ma.

Present day architecture of the Bohemian Massif and location of Palaeozoic sutures

Saxothuringian is represented by Neoproterozoic par-autochthon represented by migmatites and paragneisses dated at ~580–550 Ma. These rocks are intruded by Cambro-Ordovician calc-alkaline porphyritic granodiorites converted to augen orthogneiss during the Variscan orogeny. The basement is unconformably covered by Cambrian and Ordovician sequences overlain by Late Ordovician to Famennian pelagic sediments and Famennian to Visean flysh. The par-autochthon is thrust by allochthonous units containing deep water equivalents of the Ordovician to Devonian rocks of the para-autochthon and proximal flysh sediments.

The allochthonous are represented by pile of thrust sheets marked by decreasing pressure and metamorphic age from the top to the bottom (Franke, 2000; Konopásek and Schulmann, 2005).

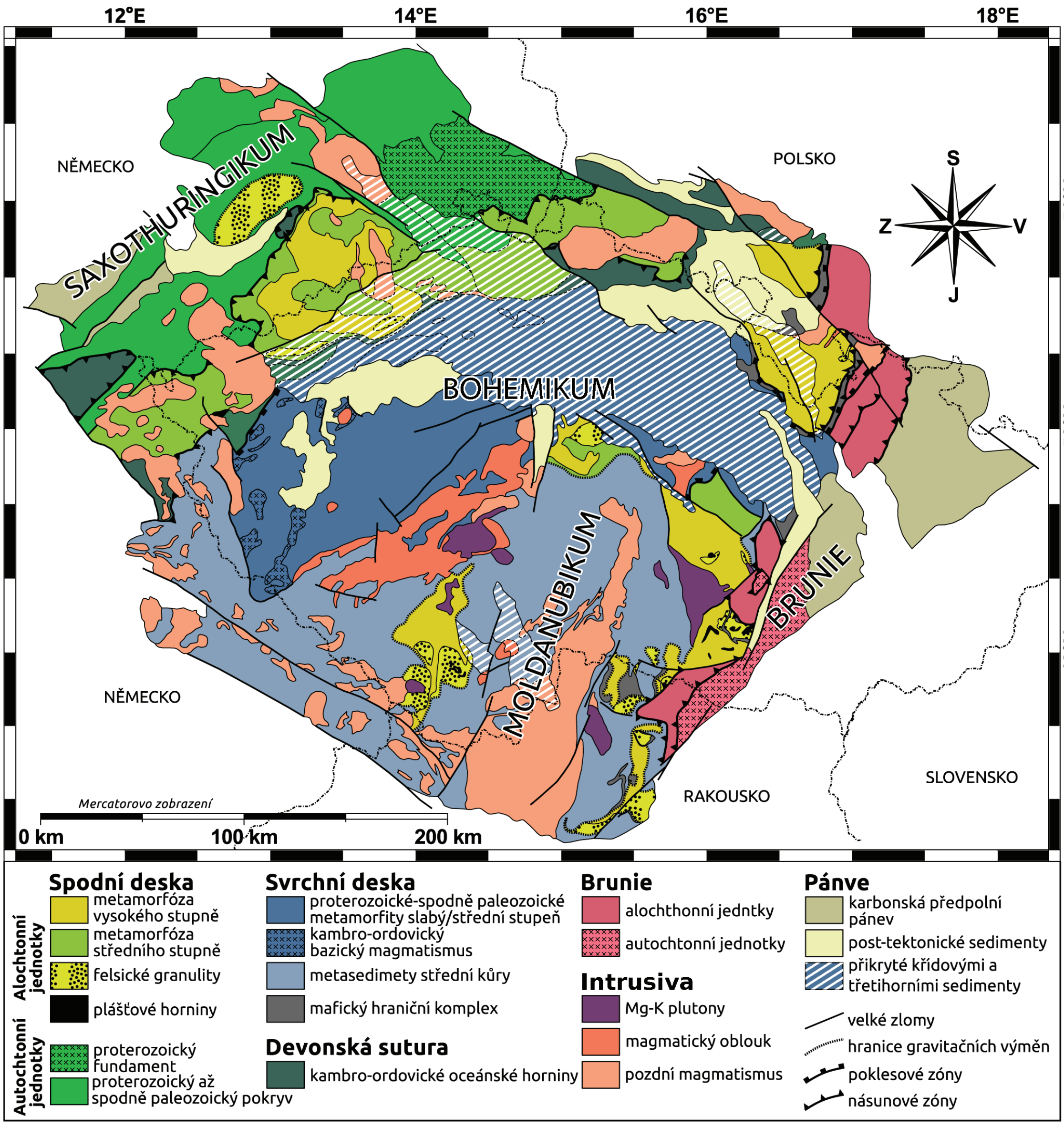


Figure 1. Plate tectonic map of the Bohemian Massif

In the highest structural position occur thrust sheets with metabasites of Ordovician protolith age eclogitized during Devonian (~395 Ma). Structurally deeper occur sheets associated with middle pressure assemblages and Late Devonian zircon and Hbl cooling ages (~365 Ma). This rock pile represents Late Ordovician to Devonian passive margin imbricated during Devonian convergence. In the Sudetic part (Figure 1, Figure 2a-c) of the Bohemian Massif, the Ordovician rift sequences are characterized by the presence of deep marine sediments and MORB type volcanics followed by Silurian and Devonian sedimentary sequences. The Ordovician oceanic rocks are metamorphosed at blueschist-facies conditions probably at Late Devonian.

The oceanic subduction stage was followed by Carboniferous continental subduction of the Saxothuringian continental rocks underneath easterly Teplá-Barrandian block which was responsible for the eclogitization of continental crust at ~350–340 Ma (Schmädicke et al., 1995). This event is responsible for the global reworking of the Saxothuringian at high pressure conditions, thrusting of subducted continental crust and exhumation of deep rocks.

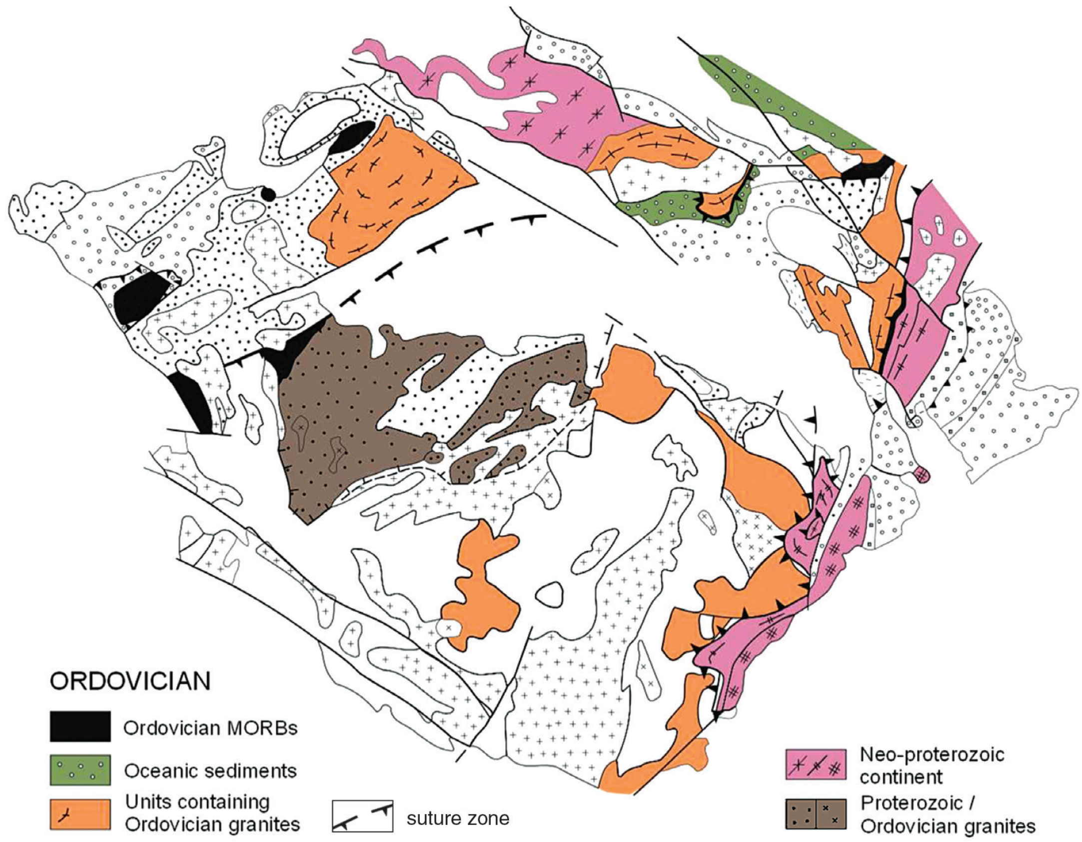


Figure 2a. Architectural evolution of the Bohemian Massif – Ordovician stage

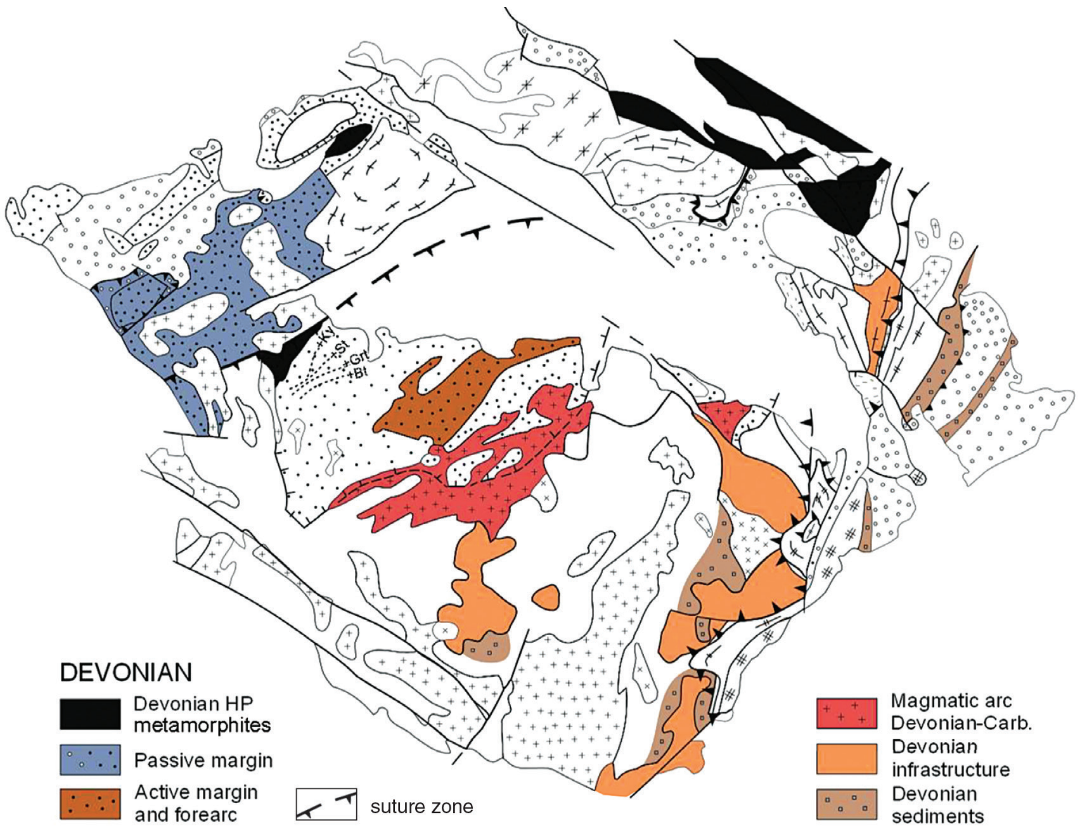
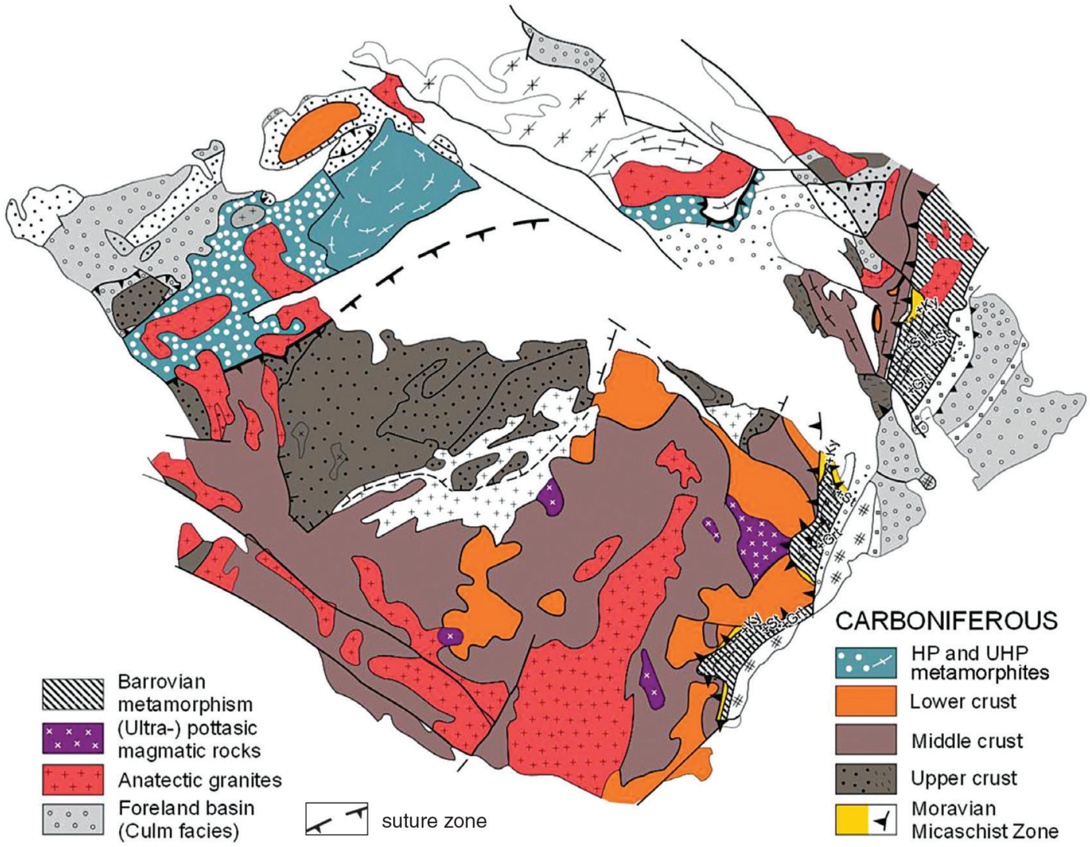


Figure 2b. Architectural evolution of the Bohemian Massif – Devonian stage



Metamorphic zones and facies: Ky – kyanite zone, St – staurolite zone, amphibolite facies, Grt – granulite facies, Bt – blueschist facies

Figure 2c. Architectural evolution of the Bohemian Massif – Carboniferous stage

The Saxothuringian – Teplá-Barrandian boundary is characterized by presence of units with high proportions of ultramafic and mafic high pressure rocks (Figure 1). Represented by serpentinites at the bottom and thick body of amphibolites, eclogites and metagabbros (Medaris et al., 1995). The protolith of gabbros and eclogites was dated as Cambrian and Ordovician while the Devonian metamorphic and cooling ages range between 410 and 370 Ma. The metamorphic evolution started with eclogite-facies metamorphism and terminated by granulite and amphibolite-facies retrogression. These rocks are interpreted as the oceanic fragment at suture position.

Teplá-Barrandian (the Bohemicum) consists of Neoproterozoic basement with the lower arc-related volcano-sedimentary sequence, followed by siliceous black shales and a flyshoid sequence (shales, greywackes and conglomerates. The Neoproterozoic basement is unconformably overlain by a thick sequence (1500–2000 m) of Lower Cambrian conglomerates, graywackes, and sandstones and Upper Cambrian volcanics. The Lower Palaeozoic Prague Basin is characterized by Early Ordovician (Tremadocian) transgression followed by mid-Ordovician rift related volcanics. Sedimentation of Silurian graptolite shales was associated with important volcanic activity accompanied by basaltic and ultramafic intrusions. The sedimentation continued from Upper Silurian to Devonian by carbonate dominated sequence and terminated at mid-Devonian with Givetian calc turbidites.

The whole sedimentary package is folded by steep folds presumably of Late Devonian age as indicated by Culm facies sediments unconformably deposited on folded Early Paleozoic strata. The deformation affected also the underlying Neoproterozoic basement, with the intensity and age increasing progressively to the west (Zulauf, 2001). In the same direction rises also the metamorphic degree, reaching amphibolite-facies conditions close to the Teplá-Barrandian/ Saxothuringian boundary. In this area is developed a typical Barrovian metamorphic zonation ranging from biotite zone in the east up to kyanite zone in the west dated at middle Devonian by $^{40}Ar/^{39}Ar$ method (Dallmeyer and Urban, 1988).

The Teplá-Barrandian and Moldanubian domain boundary is masked by the Central Bohemian Plutonic Complex. Its activity started with intrusions of calc-alkaline Devonian (~370 Ma) tonalites to granodiorites transformed into orthogneisses. The first unmetamorphosed plutonic rocks were Late Devonian (~354 Ma) calc-alkaline tonalites, granodiorites, trondhjemites, quartz diorites and gabbros. The source of the basic magmas was a slightly depleted mantle above a subduction zone. Further south/southeast occur Early Carboniferous (~349–346 Ma) high-K calc-alkaline plutonic bodies (mainly granodiorites with minor quartz monzonite and monzogabbro bodies). The intermediate rock types resulted from mixing of slightly enriched mantle-derived and crustal magmas. Finally, further east occur syn-deformational bodies or post-tectonic elliptical intrusions of magnesio-potassic rocks of mid-Carboniferous (~343–337 Ma) ages. The plutonic bodies contain numerous xenoliths, screens of the Barrandian-like Palaeozoic and Neo-Proterozoic rocks.The Central Bohemian Plutonic Complex is interpreted as a relatively shallow section (< 10 km) through the Devonian-Carboniferous magmatic arc, which widened and expanded to the east with time.

The Moldanubian is subdivided into two tectonic units: The Drosendorf Unit composed of the "Monotonous Group" represented by Proterozoic metasediments, with numerous Late Proterozoic to Early Palaeozoic orthogneisses, quartzites and amphibolites and the "Varied Group" composed of plagioclase-bearing paragneiss quartzites and marbles intercalated with amphibolites and leptynites (Tollmann et al., 1982). The protoliths of varied metasediments are supposed to be at least partly Early Palaeozoic in age with predominance of Ordovician zircons. Structurally highest is the "Gföhl Unit" composed of orthogneiss with Ordovician protolith ages, amphibolitized eclogites, granulites, garnet- and spinel-bearing peridotites surrounded by felsic migmatites.

Two NW-SE trending belts of high-pressure rocks (granulites, eclogites and peridotites) are distinguished: the western belt located close to the Barrandian–Moldanubian boundary, and the eastern belt rimming the eastern margin of the Bohemian Massif (Medaris et al., 1995). These two belts alternate with NW-SE trending wide belts represented by the Varied and Monotonous groups.

The amphibolite-facies metamorphism developed on the regional scale in the Drosenforf Unit and reflects maximal pressures of 10 kbar at temperatures of 650–700 °C. However, higher grade (eclogitic) boudins have been identified, generally at the boundary between both groups. Metamorphism of the Gföhl unit is characterized by early eclogite facies followed with granulite-facies and amphibolite-facies retrogression (O'Brien and Rötzler, 2003). The age of early high-pressure metamorphism was probably Late Devonian and the granulite-facies overprint is of Viséan age as shown by a number of zircon ages.

The deformation history in the Moldanubian Zone reveals early vertical NNE-SSW trending fabrics, associated with crystallization of high-pressure mineral assemblages. These steep foliations are reworked by flat deformation fabrics that are associated with medium- to low-pressure and high-temperature mineral assemblages. The sub horizontal foliations bear intense NE-SW trending mineral lineation that is commonly associated with generalized ductile flow towards NE. The early sub-vertical fabrics is dated at 350 to 340 Ma, while the ages for the sub-horizontal vary around 335 Ma. In the SW part of the Moldanubian domain, younger set of steep NW-SE metamorphic fabrics reworks the flat foliation, having been associated with low-pressure metamorphic conditions at around 325–315 Ma (Schulmann et al., 2005).

The Moldanubian metamorphic units are commonly intruded by numerous Variscan plutons including magnesio-potassic syenites to melagranites (durbachites), and S-type granitoids. The magnesio-potassic syenites to melagranites are spatially, structurally and temporally associated with high-pressure granulites (Janoušek and Holub, 2007). These rocks have isotopic signatures indicating a metasomatized lithospheric mantle source, presumably contaminated by subducted mature crustal material.

The Moldanubian – Brunia continental transition zone was defined as a zone of medium grade metamorphism called the Moravo-Silesian Zone (Suess, 1926). This zone of intense deformation resulted from thrusting of the Moldanubian over Brunia continent to the east. The contact between these units is marked by a particular unit, the Moravian "micaschist zone", which is composed of kyanite-bearing micaschists. This first order tectonic boundary contains boudins of eclogites, high-pressure granulites and peridotites embedded in the metapelites of both Moravian and Moldanubian parentage order tectonic boundary.

The underlying Moravo-Silesian Zone is characterized by two nappes composed of orthogneiss at the bottom and metapelite sequence at the top. This nappe sequence is overlying Neoproterozoic basement which is often imbricated with Pragian to Givetian cover. The orthogneisses of the Moravian Zone are derived from the underlying Brunia continent. This zone of intense deformation, 50 km wide and 300 km long, is marked by a tectonically inverted metamorphic sequence ranging from chlorite to kyanite-sillimanite zones. The metamorphism is interpreted as a result of continental underthrusting associated with intense top to the NNE oriented shearing. The subsequent deformation is connected with recumbent folding and imbrication of Neoproterozoic gneisses with Devonian cover. The age of this later phase is constrained at 340–325 Ma $^{40}Ar/^{39}Ar$ ages (Fritz et al., 1996).

The Brunia continent originally called the Brunovistulicum by Dudek (1980) consists of Neoproterozoic migmatites and schists dated at ~680 Ma and intruded by 550 Ma old granites. This basement is unconformably overlain by Cambrian and Ordovician strata followed by Lower Devonian quartzites and conglomerates and Givetian carbonate platform sedimentation. Since Early to Late Carboniferous (~350–300 Ma), foreland sedimentary environment developed resulting in deposition of 7.5 km thick Variscan flysch (Culm facies). Low-grade source rocks gradually pass to high-grade metamorphic source material marked by pyrope-rich mineral fraction and granulite pebbles dated at 340–330 Ma (Hartley and Otava, 2001, Kotková et al., 2007). Since 310 Ma deformation started of the flysch basin characterized by metamorphism and intense deformation in the west. The deformation terminated by folding of molasse sediments at ~300 Ma.

Geodynamic evolution of the Bohemian Massif

The succession of tectonic events (Figure 3) can be interpreted in terms of south-eastward (in the present-day coordinates) oceanic subduction of large Saxohuringian ocean underneath an active continental margin, obduction of the passive margin units, formation of a fore-arc

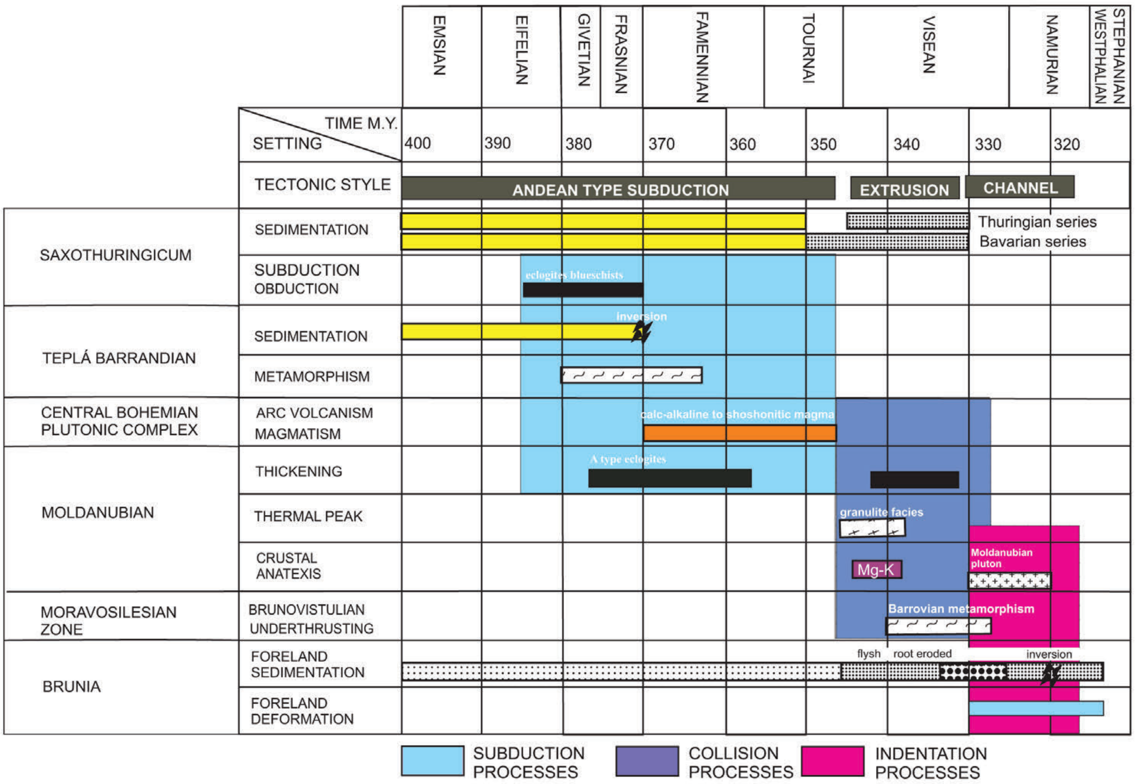


Figure 3. Chronological chart of tectonic events forming Bohemian Massif

region, growth of a magmatic arc and development of a large-scale back-arc system on the continental lithosphere. The early Saxothuringian oceanic subduction event was followed by a continental underthrusting of Saxothuringian continent leading to gradual flattening of the subduction zone marked by eastward migration of arc depocenters and subsequent crustal thickening. The latter event was responsible for the development of a thick continental root at the expense of the upper plate composed of the Teplá-Barrandian and Moldanubian units. The final evolution is marked by the continental indentation of easterly Brunia continent, exhumation of the Moldanubian lower crust, collapse of the Teplá-Barrandian and Moldanubian thrusting over Brunia platform.

Early Devonian oceanic subduction underneath the continental margin (Figure 4) is marked by relics of Ordovician to Lower Devonian passive margin metamorphosed under blueschist–eclogite facies conditions indicating a Mid-Devonian oceanic subduction. These units are obducted above a continuously underthrust continental Saxothuringian plate. The Barrovian metamorphic zonation and related deformation in the overriding Teplá-Barrandian continental margin are interpreted as ductile part of the Barrandian crust extruded during early stage of upper plate Late Devonian shortening. The steep folding of central part of anchimetamorphic Barrandian Neoproterozoic sequences is interpreted as a same deformation event but occurring in more shallow crustal levels. The subduction of a Saxothuringian oceanic crust underneath the Tepla-Barrandian crust is responsible for the origin of a magmatic arc represented by Devonian calc-alkaline orthogneisses and tonalities of the Central Bohemian Magmatic Complex and by isolated granodiorite stocks intruding Neoproterozoic sediments. At this stage the Barrandian basin operated as fore-arc domain as it is indicated by Devonian zircons in the sediments of the same age in the Prague basin. It is difficult to evaluate the original depositional origin of Moldanubian metasediments, metabasites and other high grade rocks due to severe and polyphase reworking.

Amphibolites derived from Siluro-Devonian tholeiitic basalts associated with carbonates, widespread in Lower Austria and south Bohemia, are interpreted as volcanic products of a large-scale back-arc system. In addition, the felsic metavolcanics and amphibolite layers in the Varied Group are regarded as continuity of back-arc bimodal volcanism till Givetian. The back-arc hypothesis corroborates with impressive amount of marbles with high Sr isotopic ratios that indicate shallow marine environment during Palaeozoic. A back-arc environment is further supported by bimodal volcanic activity in narrow Devonian basins developed on the north-eastern margin of the Brunia continent suggesting only minor thinning of continental crust at the easternmost termination of the back-arc system. In this concept the rest of Brunia represents a stable continental domain not affected by the back-arc spreading.

The Barrandian became a for-arc region, while the future Moldanubian continued to evolve as a crustal back-arc system. The position of high-pressure rocks, existence of the Mariánské Lázně Complex at suture position and location of calc-alkaline magmatic rocks confirm a polarity of the oceanic subduction underneath the easterly fore-arc and magmatic arc system during Late Devonian. The distance of the arc from the trench area represented by the suture indicates that the dip of subduction zone was probably moderate (30–40 degrees). The migration of magmatic centres to the east associated with temporal evolution of magma geochemistry from calc-alkaline to more potassic/shoshonitic affinities (from 370 to 336 Ma) are compatible with flattening of the subduction zone during Early Carboniferous.

The Carboniferous crustal thickening is recognized in all units except the Teplá-Barrandian. The Saxothuringian domain is characterized by the arrival of the continental crust and its subduction underneath the easterly Teplá-Barrandian–Moldanubian. The main thrust boundary migrated further west, so that the continent was thrust underneath the fossil Devonian suture and former fore-arc region. At the same time the deformation regime changed in the far field back-arc region, which recorded progressive thickening of the whole previously thinned and thermally softened domain. Recent structural studies have shown that the earliest preserved fabrics have been sub-horizontal, which may indicate that the lower crustal material was flowing horizontally from the area of subduction channel towards region of easterly back stop.

Indeed, the influx of lower crustal material transported by east dipping Saxothuringian continental subduction zone underneath the fore arc (Teplá-Barrandian) and subsequently towards the former back-arc domain is regarded to be at the origin of the future "Gföhl Unit". This hypothesis is in line with the whole-rock geochemical and Sr-Nd isotopic composition as well as the zircon inheritance patterns in the Moldanubian HP-HT granulites. Importantly, the crustal material involved in the subduction and extruded over the sub-arc and sub-back arc mantle lithosphere may have developed voluminous high-pressure granulites known from many regions of the Bohemian Massif. Alternatively, the back-arc domain with inherited high thermal budget from Devonian stretching may have been thickened and the partially molten lower crust may have been transported downwards and transformed to high-pressure granulites.

The onset of thickening of the root is not recorded in the Teplá domain, which behaved as a supra-structural domain at this time, but it is shown by deformation in the Barrandian domain. Here, the steep fabric is well dated by adjacent syntectonic calc-alkaline plutons at about 355–345 Ma. In contrast to the west, the eastern sector records onset of loading of the Brunia

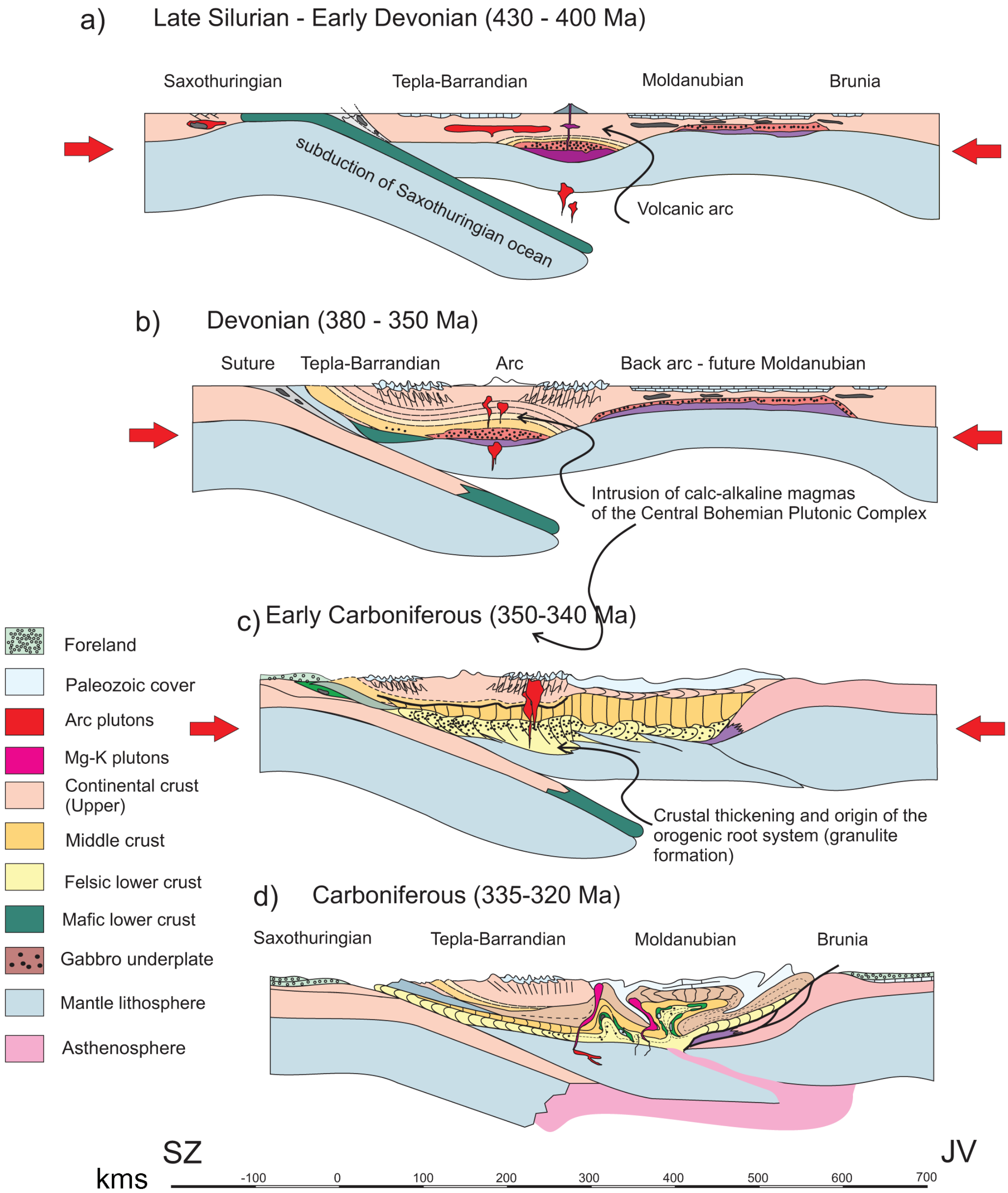


Figure 4. Geodynamics of the Bohemian Massif

platform at Tournaisian manifested by sedimentation of coarse basal clastics and destruction of the Givetian carbonate platform.

Late Visean exhumation of orogenic lower crust of the upper plate during Early Carboniferous is exemplified by the two NE–SW trending belts of granulites, eclogites and peridotites intimately associated with the magnesio-potassic plutons. The first belt, recognized west of the magmatic arc, was exhumed along huge west dipping detachment zone, which was also responsible for collapse of the upper part of the magmatic arc system and downthrow of the whole Barrandian section. Such a huge vertical material transfer could have been responsible for vertical exchange of lower crustal and upper crustal material in a range of 50 km with final throw of 15 km. The cooling ages from the lower crustal domain show that the granulites passed the 300 °C isotherm during Carboniferous, suggesting that the lower crustal bulge reached very shallow position in the upper plate.

The second lower crustal belt rims the eastern margin of the Bohemian Massif, i.e. the boundary with the Brunia continent. Here the fabric of granulites is also vertical and is interpreted in terms of massive vertical exchanges with orogenic middle crust. The zone of lower crustal bulge is interpreted as enormous anticline extrusion surrounded by middle crust coevally transported downwards in form of huge crustal scale synforms. The model of vertical extrusion is based on the concept of buckling of lower and mid-crustal interface followed by growth of crustal scale antiforms. This process is thought to be triggered by rheological and thermal instabilities in the arc region, while to the east it is forced by rigid back-stop, preserved only locally.

However, the most important feature of the eastern Variscan front is the development of horizontal fabrics in the Moldanubian root zone, parallel to the Brunia continental margin. The intense deformation of the Brunia leading to the formation of Moravo-Silesian imbricated nappe system, the origin of crustal mélange forming the Moravian micaschist zone and mixed high-pressure rocks and migmatites in the overlying Moldanubian nappe have been recently interpreted in terms of indentation of the Brunia continent into the hot and thick continental root. This lower crustal indentation and flow of hot lower crustal rocks in supracrustal levels are consistent with the model of continental channel flow driven by arrival of crustal plunger, a model which is advocated for two decades for the deformation of the Eastern Cordillera in the Andes. Finally, the load of Brunia platform related to deep indentation process, leads to the development and easterly propagation of the foreland basin associated with progressive involvement of the early clastic basin infill into the channel flow process. In our model (Schulmann et al., 2008) as the hot Moldanubian rocks advances over the Brunia platform, the imbricate footwall nappe system of the Moravian zone is generated and thrust over the foreland basin rocks.

References

Dallmeyer, R.D. & Urban, M. 1998. Variscan vs Cadomian tectonothermal activity in northwestern sectors of the Teplá-Barrandian zone, Czech Republic: constraints from 40Ar/39Ar ages. Geologische Rundschau, 87, 94–106.

Dudek, A., 1980. The crystalline basement block of the Outer Carpathians in Moravia. Rozpravy Československé Akademie Věd, 90, 1–85.

Franke, W., 2000. The mid-European segment of the Variscides: Tectonostratigraphic units, terrane boundaries and plate tectonic evolution. In: Orogenic processes: Quantification and modelling in the Variscan belt. (ed Franke, W., Haak, W. Oncken, O. and Tanner, D.) 179, pp. 35–63, Geological Society Special Publication, London.

Fritz, H., Dallmeyer, R. D. & Neubauer, F., 1996. Thick-skinned versus thin-skinned thrusting: Rheology controlled thrust propagation in the Variscan collisional belt (The southeastern Bohemian Massif, Czech Republic – Austria). Tectonics, 15, 1389–1413.

Hartley, A. J. & Otava, J., 2001. Sediment provenance and dispersal in a deep marine foreland basin: The Lower Carboniferous Culm Basin, Czech Republic. Journal of the Geological Society, 158, 137–150.

Janoušek, V. & Holub, F. V., 2007. The causal link between HP-HT metamorphism and ultrapotassic magmatism in collisional orogens: Case study from the Moldanubian Zone of the Bohemian Massif. Proceedings of the Geologists‘ Association, 118, 75–86.

Konopásek, J. & Schulmann, K., 2005. Contrasting Early Carboniferous field geotherms: Evidence for accretion of a thickened orogenic root and subducted Saxothuringian crust (Central European Variscides). Journal of the Geological Society, 162, 463–470.

Kotková, J., Gerdes, A., Parrish, R.R., & Novák, M., 2007. Clasts of Variscan high-grade rocks within Upper Viséan conglomerates – constraints on exhumation history from petrology and U-Pb chronology. Journal of Metamorphic Geology, 25, 781–801.

Medaris, G., Jelínek, E. & Mísař, Z., 1995. Czech eclogites: terrane settings and implications for Variscan tectonic evolution of the Bohemian Massif. European Journal of Mineralogy, 7, 7–28.

O‘Brien, P. J. & Rötzler, J., 2003. High-pressure granulites: formation, recovery of peak conditions and implications for tectonics. Journal of Metamorphic Geology, 21, 3–20.

Schmädicke, E., Metzyger, K., Cosca, M.A. & Okrusch, M. 1995. Variscan Sm–Nd and Ar-Ar ages of eclogite-facies rocks from the Erzgebirge, Bohemian Massif. Journal of Metamorphic Geology, 13, 537–552.

Schulmann, K., Kröner, A., Hegner, E., Wendt, I., Konopásek, J., Lexa, O. & Štípská, P., 2005. Chronological constraints on the pre-orogenic history, burial and exhumation of deep-seated rocks along the eastern margin of the Variscan orogen, Bohemian Massif, Czech Republic. American Journal of Science, 305, 407–448.

Schulmann, K., Lexa, O., Štípská, P., Racek, M., Tajčmanová, L., Konopásek, J., Edel, J.-B., Peschler, A., Lehmann, J., 2008. Vertical extrusion and horizontal channel flow of orogenic lower crust: key exhumation mechanisms in large hot orogens? Journal of Metamorphic Geology 26, 273–297.

Schulmann, K., Konopásek, J., Janoušek, V., Lexa, O., Lardeaux, J.-M., Edel, J.-B., Štípská, P., Ulrich, S., 2009. An Andean type Palaeozoic convergence in the Bohemian Massif. Comptes Rendus Geoscience 341, 266–286.

Suess, F. E., 1926. Intrusionstektonik und Wandertektonik im variszichen Grundgebirge. Borntträger, Berlin.

Tollmann, A., 1982. Großräumiger variszischer Deckenbau im Moldanubikum und neue Gedanken zum Variszikum Europas. Geotektektonische Forschungen, 64, 1–91.

Zulauf, G. 2001. Structural style, deformational mechanisms and paleodifferential stress along an exposed crustal section: constraints on the rheology of quartzofeldspathic rocks at supra- and infrastructural levels (Bohemian Massif). Tectonophysics, 332, 211–237.

Žák, J., Holub, F.V. & Verner, K. 2005. Tectonic evolution of a continental magmatic arc from transpression in the upper crust to exhumation of mid-crustal orogenic root recorded by episodically emplaced plutons: the Central Bohemian Plutonic Complex (Bohemian Massif). International Journal of Earth Sciences, 94, 385–400.

Paleogeographic evolution of the Bohemian Massif

Over the last 25 years of the 20th century, geology has collected and continues to collect so much information from global tectonics, paleontology, geophysics and geochemistry that it is possible to synthesise the paleogeographic evolution of our planet for over 1 billion years.

Paleogeographic reconstructions in the form of paleocontinent and paleoocean maps are usually available only from the Upper Proterozoic, or Neoproterozoic, namely the Ediacaran (= Vendian), i.e. from around 600 Ma. Their detail varies. They differ in the contours of the continents, the enumeration of the mentioned micro-continents, oceans and seas, rifts, subduction zones. By default, island arcs are not mentioned. But these played an important role in orogenesis and sometimes in the migration of organisms, so they are important for paleogeography. Reconstructions also partially differ in dates of certain configurations of the paleogeographic situation.

These facts create conditions and circumstances of the paleogeographic reconstruction of the Bohemian Massif.

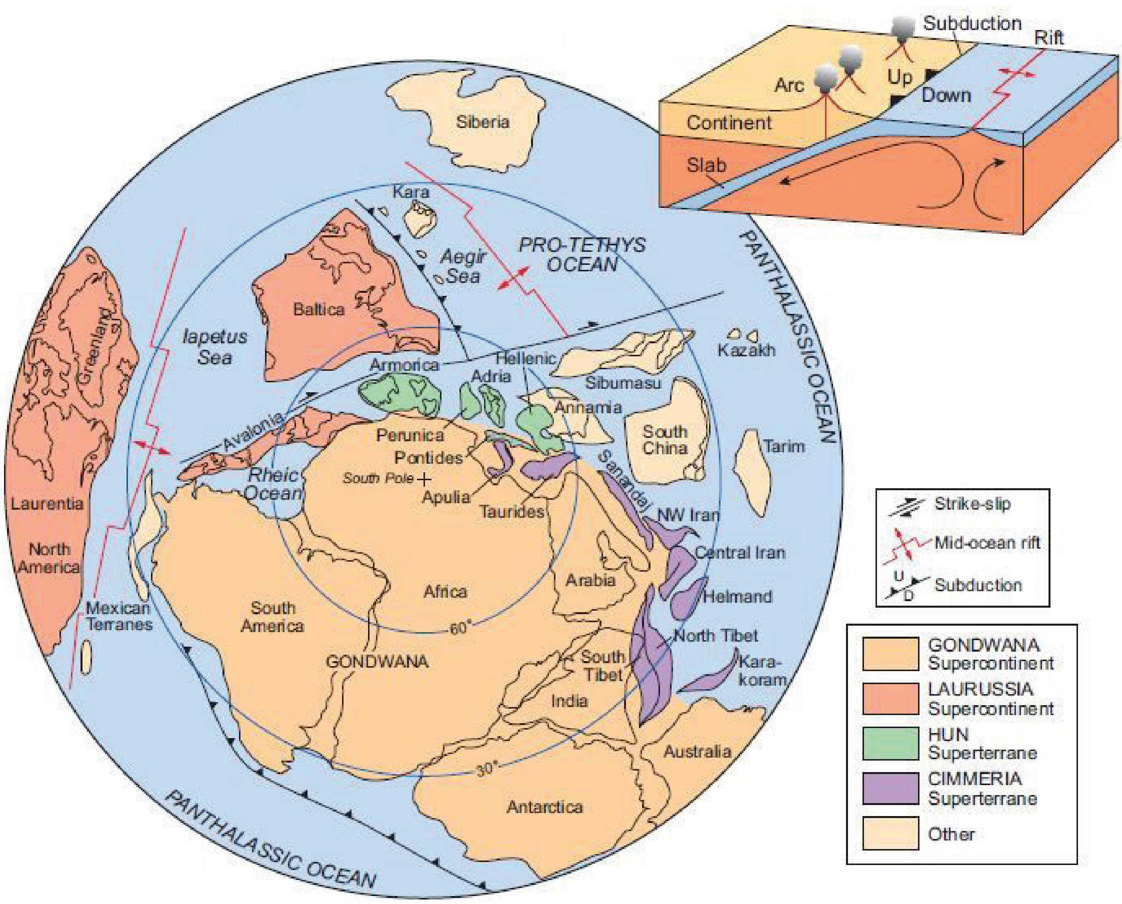


Figure 1. Paleogeography of Upper Cambrian (before 500 Ma).
Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

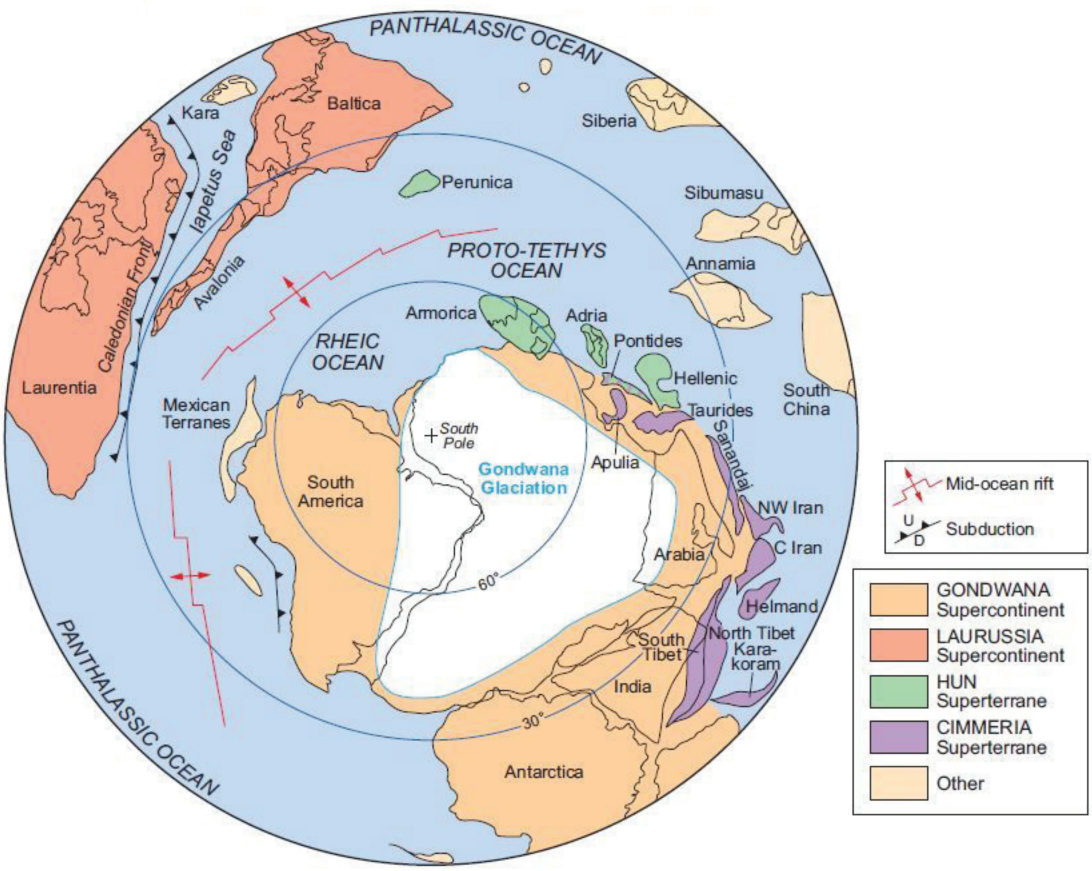


Figure 2. Paleogeography of the boundary of the Uppermost Ordovician and Lowermost Silurian (before 440 Ma). Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

The oldest rocks of today‘s Bohemian Massif originated in the range of 1000–545 Ma in the Neoproterozoic (see the previous chapter “Geological evolution of the area of the Czech Republic” in this publication). At that time (Scotese Ch. R. (2001, 2014)), they were part of the supercontinent Rodinia at first. Its disintegration into two halves – continents – separated by the Panthalassic and Pan-African Oceans before 750 Ma was followed by the separation of the Congo Craton – the third continent – from the northern one of the two. It probably included rocks of the Bohemian Massif (Brunia) and was located in the equatorial zone. The oceans between the three continents were completely subduced and formed the Pannotia supercontinent (650–500 Ma) in the southern hemisphere (a collision known as Cadomian and Pan-African orogenesis). But Pannotia began to disintegrate soon after its formation and disintegrated (before 560 Ma) to form the Iapetus Ocean and the Tornquist Sea into the continents of Laurentia, Siberia, Baltica and Gondwana. The rocks of the Bohemian Massif together with other African rocks were part of Gondwana near the South Pole. Under unknown circumstances, some of them were separated from Gondwana and, in a form of a larger island (microcontinent), moved northward in the upper Cambrian from the area between the South Pole and the South Polar Circle. It was accompanied and followed by a set of similar separated islands – microcontinents – collectively called the Hun Superterrane (Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007)). From this peri-Gondwanan position, the larger

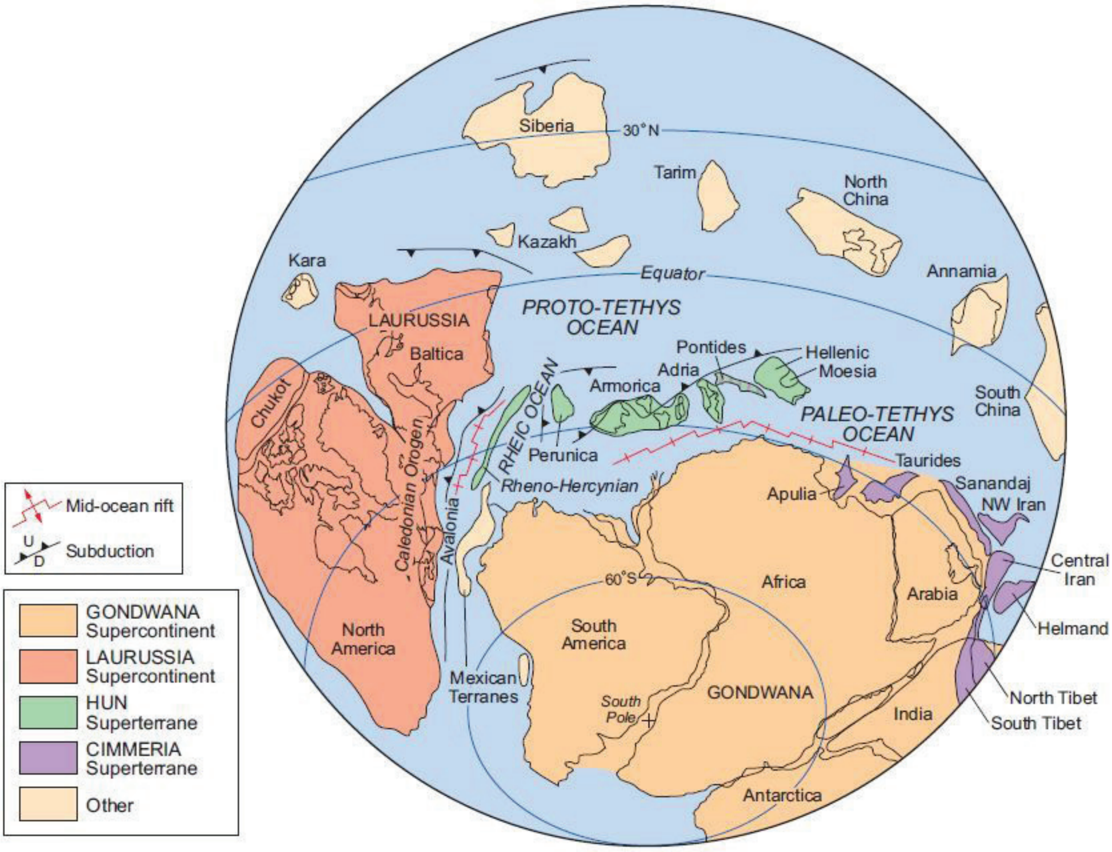


Figure 3. Paleogeography of the Early Devonian (before 400 Ma).
Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

(but westward) neighbouring Avalonia followed them in the Lower Ordovician. Avalonia was separated from Gondwana by the emerging rift of the future Rheic Ocean and from the Baltica by the rift of the Tornquist Sea (or Ocean). (Cocks, L.R.M. – Torsvik, T.H. (2006), Fatka, O. – Mergl, M. (2009)).

Wandering island – the seed of today‘s Bohemian Massif – was called the microcontinent Perunica by Havlíček V. et al. (Havlíček, V. – Vaněk, J. – Fatka, O. (1994)). During its pilgrimage to the north, it was part of a long-term subduction process of considerable magnitude (see the previous chapter “Geodynamics of the origin of the Bohemian Massif covering the territory of the Czech Republic” in this publication), that developed over at least 500 km in current coordinates in the time period from Silurian to Carboniferous.

About 450 Ma, at the turn of Ordovician and Silurian, Avalonia reached Baltica by the Tropic of Capricorn and collided with Laurentia. The collision created a Caledonian Orogeny on the continent called Laurussia and also Euramerica. At the same time, the Iapetus Ocean between Laurentia and Avalonia and the Tornquist Sea between Laurentia and the Baltica enclosed, and the opening of the Rheic, Ran and Themis Oceans continued.

Perunica crossed the south polar circle at the turn of the Upper Cambrian and Lower Ordovician (about 490 Ma). In the Lower Devonian (400 Ma), it was located by the Tropic of Capricorn. In the Upper Devonian to the Lower Carboniferous (370–340 Ma), it moved in

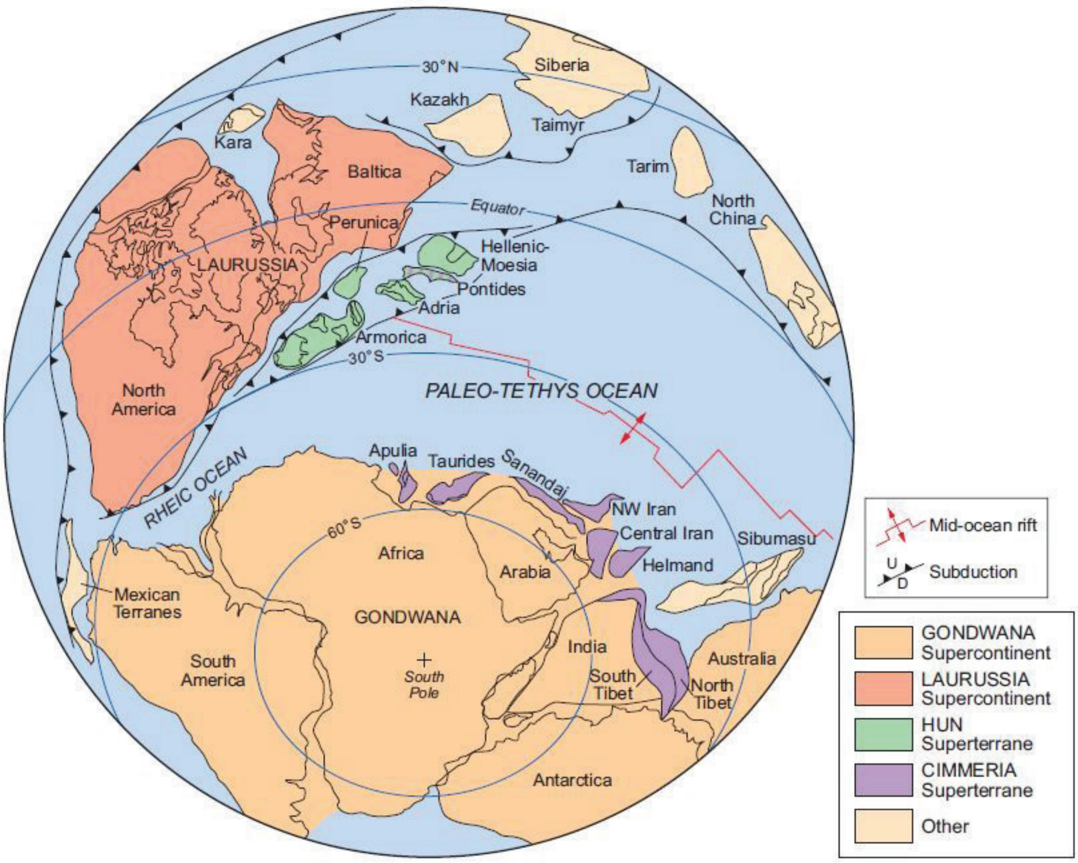


Figure 4. Paleogeography of the Early Carboniferous (Mississippian before 340 Ma). Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

the tropical zone south of the equator. A collision with Laurussia happened to it in this zone at the end of the Carboniferous. The collision was part of the formation of the Variscan Orogen. The Variscan Orogen results from numerous other collisions of the microcontinent of the Hun superterrane with Laurussia, including Armorica (a set of Armorican lithological units – Armorican Terrane Assemblage), Adria and Hellenic lithological unit (Hellenic Terrane), and from Laurussia‘s direct collision with Gondwana. In European Variscides emerging from Middle Devonian to Upper Carboniferous (390–310 Ma), Armorica is the basis of their western part, Perunica of their eastern part.

After the incorporation of Perunica into the variscides of Laurussia, Perunica shared the fate of Laurussia. That included: the closure of the Rheic Ocean and opening of the Paleo-Tethys Ocean and the Panthalassic Ocean, and the collision of Laurussia with Gondwana that formed the Pangea supercontinent in the Upper Carboniferous (before 330 Ma), the disintegration of Pangea in the Jurassic (before 150 Ma) that formed Laurasia and the division of Laurasia by the Atlantic Ocean into North America and Eurasia in Cretaceous (before 90 Ma). Eurasia represents the last anchorage of the Bohemian Massif within its paleogeographic evolution.

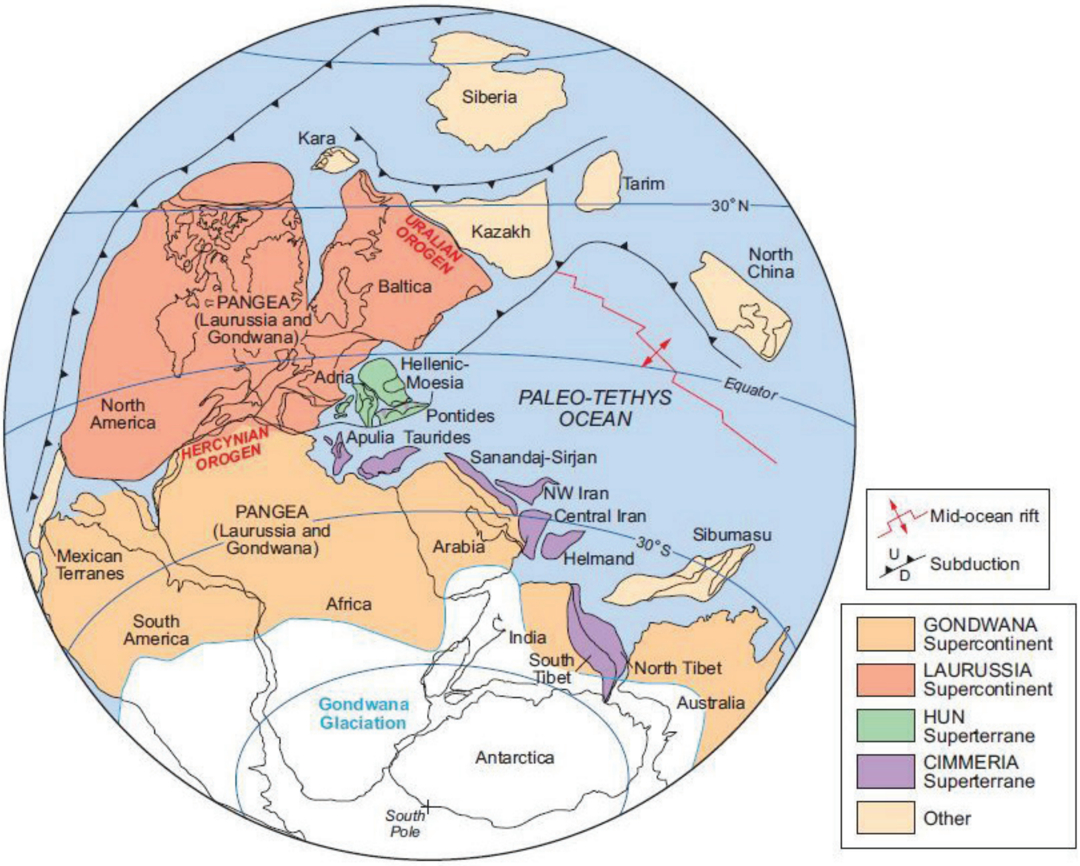


Figure 5. Paleogeography of the Late Carboniferous (Pennsylvanian before 310 Ma). Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

References

Cocks L.R.M. – Torsvik T.H. (2006): European geography in a global context from Vendian to the end of the Paleozoic. – In: Gee D.G. – Stephenson R.A. (editoři): European lithosphere dynamics, Geological Society, London, Memoirs, 32: 83–95. Geological Society of London.

Domeier M. (2016): A plate tectonic scenario for the Iapetus and Rheic oceans. – Gondwana Research, 36: 275–295.

Edel J.B. – Schulmann K. – Lexa O. – Lardeaux J.M. (2018): Late Palaeozoic palaeomagnetic and tectonic constraints for amalgamation of Pangea supercontinent in the European Variscan belt. – Earth-Science Reviews, 177: 589–612.

Fatka O. – Mergl M. (2009): The ‚microcontinent‘ Perunica: status and story 15 years after conception. – In: Bassett M.G. (editor): Early Paleozoic Peri-Gondwana terranes-new insights from tectonics and biogeography. Geological Society, London, Special Publications, 325: 65–101.

Havlíček V. – Vaněk J. – Fatka O. (1994): Perunica microcontinent in the Ordovican (its position within the Mediterranean Province, series division, benthic and pelagic associations). – Sborník geologických věd, Geologie 46: 23–56.

Havlíček V. (1999): Perunica microplate: relation to Ukrainian Shield, mid-Bohemian rift, and

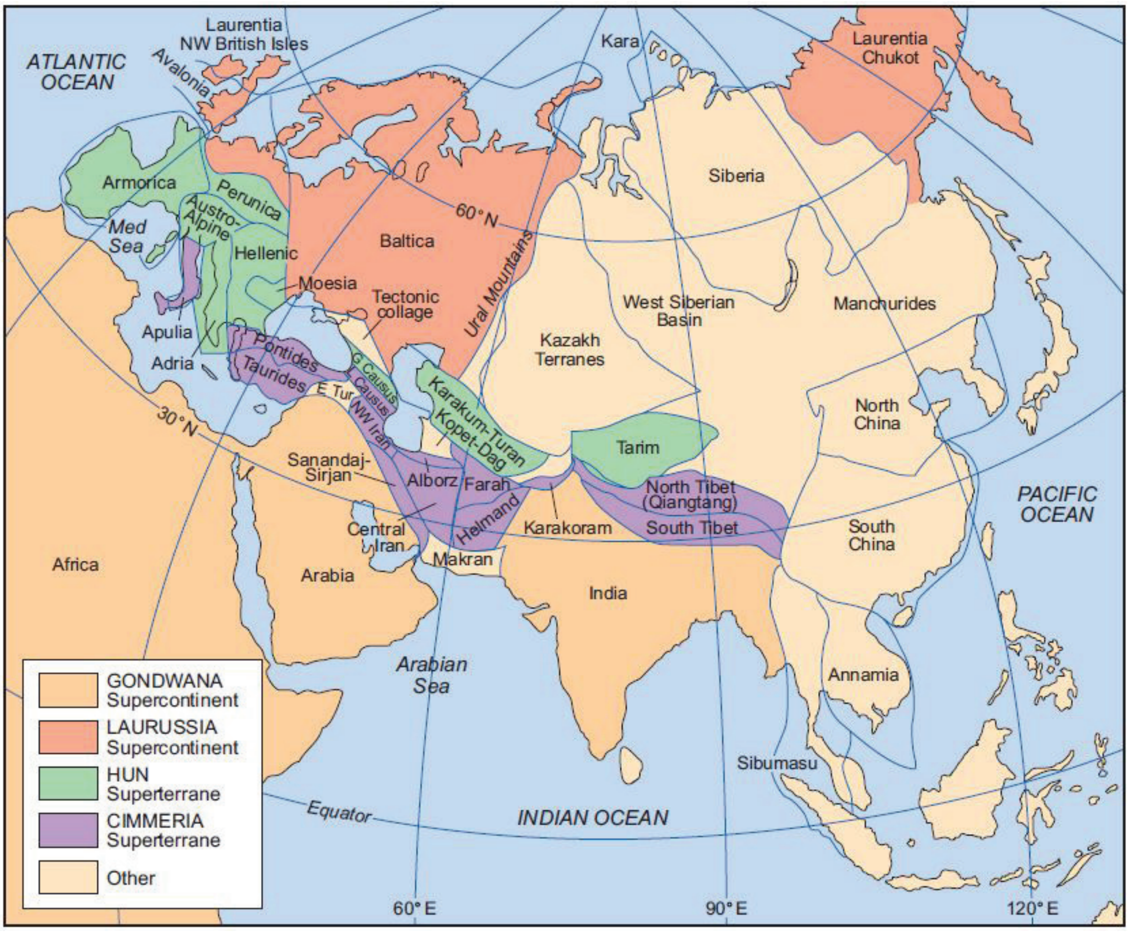


Figure 6. Current position of Palaeozoic supercontinents, continents and lithological units. Ruban, D. A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

hypothetic large-scale overthusts in central Bohemia. – Věstník Českého geologického ústavu (Bulletin of the Czech Geological Survey), 74, 1: 75–81.

Kachlík V. (2003): Geologický vývoj území České republiky. – 64 stran, Ústav geologie a paleontologie, Přírodovědecká fakulta Univerzity Karlovy, Správa úložišť radioaktivních odpadů. Praha.

McCann T. (editor) (2008): The geology of Central Europe. Volume 1: Precambrian and Paleozoic. – 748 stran, Geological Society of London.

Murphy J.B. – Keppie J.D. – Nance R.D. – Dostal J. (2010): Comparative evolution of the Iapetus and Rheic Oceans: A North America perspective. – Gondwana Research, 17: 482–499.

Ruban D.A. – Al-Husseini M.I. – Iwasaki Y. (2007): Review of Middle East Paleozoic plate tectonics. – GeoArabia, 12, 3: 35–56.

Scotese Ch.R. (2001, 2014): Atlas of Earth history. Volume 1, Paleogeography. – Paleomap Project, Department of geology, University of Texas at Arlington. https://www.researchgate.net/publication/ 264741875_Atlas_of_Earth_History

Torsvik T.H. – Cocks R.M. (2013): Chapter 2 New global paleogeographical reconstructions for the Early Paleozoic and their generation. – In: Harper D.A.T. – Servais T. (editoři): Early Paleozoic biogeography and paleogeography. Geological Society, London, Memoirs, 38: 5–24. Geological Society of London.

MINERALS CURRENTLY MINED IN THE CZECH REPUBLIC

ENERGY MINERALS

Significant geological reserves of energy minerals on the territory of the Czech Republic can be found only in uranium ores, bituminous coal and brown coal. Geological reserves of these raw materials take a share of rounded 1 per cent in the world reserves. Brown coal deposits are concentrated in the Krušné Hory Mts. Piedmont Basins. About over one third of domestic electric energy and nearly half of heat (heating plant) production is covered by coal from these basins. All the bituminous coal mining is at present concentrated in the Czech part of the Upper Silesian Basin. Uranium mining has been abandoned. Coal production started to thrive on the Czech territory in the 19th century in the beginning of the industrial revolution. After the World War II, uranium ore mining developed. Production of energy minerals as a whole reached its peak in the second half of the 1980´ and after that a recession came connected with the decline of U-ore and all kinds of coal mining.

Uranium is an important Czech energy mineral with a share of 37% in total domestic production of electricity. The Czech Republic was one of the world's most important uranium producers and historically with a total production of over 113 kt of uranium in the years 1946 to 2018 in the form of sorted ores (from the beginning of mining until 1975) and chemical concentrate (since 1953) is on 12th rank in the world. The closure of the last mined deposit for economic reasons in 2016 probably ended (if not definitively) uranium mining in the Czech Republic for a long time. The total amount of mine output in the Czech Republic and its share in world mining has been constantly declining. While in 1990 it reached more than 4%, between 1994 and 2003 it was around 2%, after 2005 it has already fallen below 1% and currently (2021) our republic with uranium production below 30 t per year is far behind 10th rank in the world with less than 0.1% share in the world mining. At present, uranium is obtained as a side effect of groundwater treatment as part of disposal operations after in situ leaching of uranium ores.

Crude oil was one of the few minerals in the Czech Republic, the extraction of which was constantly growing until 2003. After that, it remained stable for two years and has been declining since 2006. The main reason for the decline in the last three years, there has been a decline in world prices, but also high royalty tariff on extracted mineral. Exports are negligible and are around 0.4% relative to domestic mining. However, the total share of extracted oil in the Czech Republic in domestic consumption has long been only between 1.5 and 2%. The deposits are located in the Carpathian foredeep and the Vienna Basin.

The share of domestic natural gas production in recent years covers domestic annual consumption of about 2%. The average annual production volume has long been maintained at the level of 120–150 million m^3, from 2010 to 2015 it stabilized at values of around 200 million m^3 per year. After that, it ranged from less than 170–180 million m^3 and in 2019 it fell to 146 million m^3. Czech gas production in 2021 reached 153 million m^3. The reason for the decline in extraction was mainly the worldwide decline in prices. The most significant accumulations of natural gas in South Moravia are tied to the Carpathian foredeep region and South-East slopes of the Bohemian Massif. These deposits are often associated with crude oil. In northern Moravia, Carboniferous natural gas deposits (coal mine methane – CMM) mined from closed underground bituminous coal mines in the Czech part of the Upper Silesian Basin (so-called degassing of coal seams) are of the greatest importance.

Bituminous coal is an important Czech energy and metallurgical raw material. Although its share is constantly declining slightly, it still produces around 6% of domestic electricity and 13.5% of heat. Gross annual bituminous coal mining in the Czech Republic has been a long time (from 1973 to 1990) relatively stable and ranged between 33 and 38 million tons, with a record in 1975, when 38.6 million tons of bituminous coal were mined. In this period, disposable (and similarly saleable) mine production was around 28 million tons per year, and in the case of the Upper Silesian Basin it accounted for between 75 and 80% of gross extraction. Bituminous coal mining in the Czech Republic has had a declining trend since 1990. From 2013, the consequences of the decline in world prices of steam coal began to manifest themselves, and mining gradually fell to 1.861 million tons in 2020. In 2021 reached the bituminous coal production 2.008 millions ton. Saleable output is always somewhat different from the decline in coal reserves. Higher saleable output is related to the processing and sale of coal from dumping grounds, washery plants, etc., on the contrary, lower sales production reflected a decrease in interest in bituminous coal on the market and thus a part of mined raw material was deposited in dumping grounds. Roughly half (over 46%) of the coal mined in the Czech part of the Upper Silesian Basin is coking coal, and slightly less is steam coal. The remaining 7% is PCI (pulverized coal injection) coal, which is mainly used in iron processing. Btuminous coal is currently mined only in the Czech part of the Upper Silesian Basin.

Brown coal is the most important Czech energy mineral. It produces about 43% of domestic electricity and 44% of heat. Mining takes place only in the North Bohemian and Sokolov basins. The peak of lignite mining in the Czech Republic was in the 1980s, when gross annual mine output ranged from 91 to almost 97 million tons per year (the highest 96.9 million tons in 1984). Both disposable and saleable extraction almost copied gross output and differed minimally in individual years. Since 1988, when mining last exceeded 91 million tons, it has been gradually declining. In 2019, mining decreased slightly to 37.5 million tonnes and the decline continued in 2020 to 29.5 million tonnes. In absolute numbers both basins contributed roughly equally. Brown coal is currently mined only in the North Bohemian Basin and the eastern part of the Sokolov Basin. The share of deposits in the North Bohemian Basin was about 80% of the total brown coal production in the Czech Republic in the whole monitored period, the highest (84%) was in 2011, 2019 and 2020. In 2019 the share of total brown coal mining in the Sokolovská Basin decreased to about 16%, otherwise was mostly less than 20%. Relatively large reserves of brown coal in northern Bohemia (North Bohemian coal basins) are blocked on the basis of the announcement of the so-called territorial limits of lignite mining in northern Bohemia. These were determined by Resolutions of the Government of the Czech Republic No. 444 of 1991, 1,176/2008 and 827/2015. The government resolution defines mining areas and areas that should remain unmined. The main reason for their determination was the protection of the environment and the landscape in the area of northern Bohemia.

Lignite is mostly classified as brown coal in the world, but in the Czech Republic it is reported separately. While in 1988 the annual production was 2.2 million tons, over the next five years it gradually decreased by almost 1 million tons. At that time, lignite was still mined in three deposits in the Vienna Basin. In 1992, the mining of the Kyjov seam in Šardice ended. Less than two years later, mining at the Dubňany deposit was terminated, and from the second half of 1994, lignite in the Czech Republic was mined in only one Hodonín deposit until mining was terminated (0.5 million tons per year, 0.3 million tons 2009) in 2009.

Bituminous coal

1. Characteristics and use

Coal is a flammable sedimentary rock (coal caustobiolite) formed by coalified organic matter (originating from peat) and mineral admixtures originating from plant bodies or from sediments coming into the coal-forming environment or from the coalification process. Coalification determines the gross combustion value, the reflectivity of vitrinite, the hydrogen content in the H combustible. Mineral admixtures (carbominerites in bituminous coal and minerites in brown coal) form the M ashes.

The internationally recognised boundary between bituminous and brown coal is not clearly defined, but it is accepted that bituminous coal has the Qsm,af (combustion heat on the anhydrous ash-free basis) equal to or greater than 24 MJ/kg at a light reflectance of vitrinite $Rr \geq 0{,}6\,\%$. Anthracites include all coals with a vitrinite reflectance $Rr \geq 2\,\%$. The limit value between meta-anthracite (most coalified anthracite) and semi-graphite is the hydrogen content in the combustible (Hh) 0.8%.

Reserves

2021		
Country	**mill t**	**%**
USA	218,938	29.1
China	135,069	17.9
India	105,979	14.1
Australia	73,719	9.8
Russia	71,719	9.5
Ukraine	32,039	4.3
Kazakhstan	25,605	3.4
Indonesia	23,141	3.1
Poland	22,530	3.0
Columbia	4,554	0.6
World	**753,639**	**100.0**

2021			
Country	**mill t**	**% world**	**% EU**
EU	25,539	3.40	100.00
Poland	22,530	3.00	88.20
Czechia	1,081	0.10	4.23
Spain	868	0.12	3.40
Hungary	276	0.04	1.08
Bulgaria	192	0.03	0.80
Romania	11	0.001	0.04

Source: BP Statistical Review of World Energy 2021 (No reserves update in the 2022 issue)

Uses

Production of electricity and heat, metallurgy, chemistry. Coking coal is defined as bituminous coal with a quality that enables the production of coke for blast furnace production of pig iron or for heating purposes. Other types of bituminous coal are referred to as steam coal, which are used mainly to generate electricity.

Classification as critical raw materials for the European Union
Coking coal 2011 – no, 2014 – yes, 2017 – yes, 2020 – yes
Steam coal 2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

There are deposits of coking and steam bituminous coal in the Czech Republic. The Czech part of the Upper Silesian Basin with an area of approximately 1,550 km^2 (approximately 30% of coal reserves are in the Czech Republic and 70% in Poland), operationally called the Ostrava-Karviná coalfield (OKR), is decisive, and there is also a significant share of coking coal. At present, this is the only area of bituminous coal mining in the Czech Republic and the company OKD, a.s., Ostrava mines here.

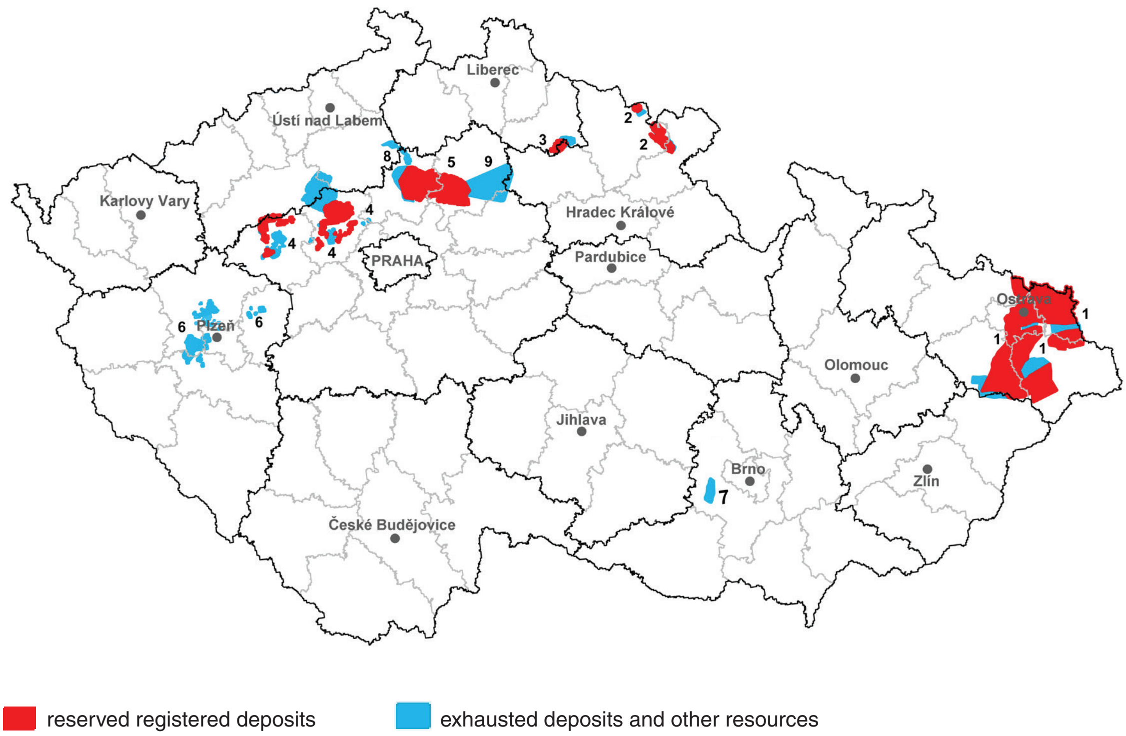
- The Bludovice fault divides the basin into two parts: the northern Ostrava-Karviná and the southern Podbeskydy. The significant tectonic fault (the Orlová Fault) divides the Ostrava-Karviná part of the basin into a western, geologically older and tectonically intensively affected Ostrava part of the basin with a paralic development of sediments[1], and the eastern, less complex Karviná part with not only paralic but also limnic[2] sediment development. The western part contains several dozen relatively low-thickness (on average approx. 0.7 m) layers of high-quality coking coal, while in the eastern part there are medium-thickness layers (on average approx. 1.8 m) with mixed coking or steam coal predominant in the recoverable depths. At present, the entire production of the basin is provided by 2 mining plants with 5 deposits (mining leases Darkov, Doubrava, Karviná-Doly I and II, Louky) in the Karviná part of the basin (in 2016 mining was terminated in mining lease Stonava and at the end of 2019 also in mining lease Lazy). The calorific value Q_i^r of the mined coal is usually between 23–30 MJ/kg, the ash content A^d between 10 and 30%. Due to long-term intensive mining, mining in the Ostrava part of the basin was getting deeper and deeper (even over 1,000 m), which, together with difficult mining and geological conditions, enormously increased the mining costs. Therefore, the mines in Ostrava became unprofitable and were gradually closed and liquidated. Most of the mines in the eastern part had sufficient reserves with a simpler geological structure, which can be mined at significantly lower costs. However, the value of this coal is reduced by its lower quality due to its coking properties.
- In the northern area of the Podbeskydy part of the basin, 1 deposit (mining lease Staříč) of predominantly coking coal in the Ostrava Formation was mined by one mine until 31 March 2017. The calorific value Q_i^r of the mined coal ranged on average between 28–29 MJ/kg, the ash content A^d between 11–19%. Relatively large coal reserves have been evaluated further south, especially in the vicinity of Frenštát pod Radhoštěm, where the coal-bearing carbon is covered with Miocene and the Beskydy nappes. Coal would be mined here under difficult geological conditions from depths of 800–1,300 metres. In addition, the deposit partially extends into the Beskydy Protected Landscape Area, and therefore its use is not yet planned.
- Until the final cessation of mining in the last 3 mining areas (Kačice, Srby, Tuchlovice) in mid-2002, the second most important area with bituminous coal reserves was the Kladno-Rakovník Basin located in Central Bohemia west of Prague. However, most of the reserves of the original Kladno-Rakovník Basin with steam coal have already been mined and the

1 alternation of marine and continental sediments
2 only lake sediments

remaining ones have lost their economic significance. The calorific value Q_i^r of the mined coal ranged on average between 18–20 MJ/kg, the ash content A^d between 20–35%. In the north-eastern continuation of the Kladno part of the basin, a deposit of relatively high-quality and partially coking coal near Slaný was identified and examined in the 1950s and 1960s, with geological (potentially economic) reserves of approximately 364 million tonnes, but lying at depths of 700–1,300 m and with complex hydrogeological and gas conditions. The average calorific value Q_i^r is between 18–22 MJ/kg, the ash content A^d between 20–40%. The opening of this deposit was stopped after the excavation of two main pits in the early 1990s, and the two pits excavated so far have been backfilled.

- Northeast of Prague, the Mšeno part of the Mšeno-Roudnice Basin with geological reserves of steam coal of over 1.1 billion tonnes was identified and preliminarily explored. The average calorific value Q_i^r is between 16–20 MJ/kg, the ash content A^d between 24–40%. However, the use of these reserves is currently unrealistic (economic aspects and conflict of interest – drinking water for the Central Bohemian region in the overlying Cretaceous sandstones). At present, the Roudnice part of this basin and the Mnichovo Hradiště Basin lying east of the Mšeno-Roudnice Basin appear to be completely unpromising.
- A low-perspective deposit of low-quality steam bituminous coal is evaluated in the Krkonoše Piedmont Basin.
- Deep mining of mainly steam coal in the Czech part of the Intra-Sudetian Basin definitively ended in the early 1990s. From 1998 to 2007, very little surface mining took place at the Žacléř deposit.
- Mining of bituminous coal in the Pilsen region (Pilsen and Radnice Basins) was also definitively terminated in the first half of the 1990s, and the remaining reserves were removed from the Register in 2002. Slight mining efforts in the adjacent Manětín and Žihel Basins and in isolated carbon relics near Mirošov, Merklín, Tlustická, Malé Přílepy, etc. were of a rather local significance.
- The mining of steam bituminous coal in the Boskovice furrow (Rosice-Oslavany mining district) west of Brno definitively ended at the beginning of 1992.
- Small isolated relics of bituminous coal to anthracite in the Blanice furrow were mined locally in the past, for example near Lhotice northeast of České Budějovice, west of Vlašim and in the Český Brod region.
- The slight mining of anthracite in the carbon relic near Brandov in the Ore Mountains has never been of significant important.

3. Registered deposits and other resources of the Czech Republic



Coal basins

*(Names of basins with mined deposits are indicated in **bold type**)*

1 **Czech part of the Upper-Silesian Basin**
2 Czech part of the Intra-Sudetic Basin
3 Krkonoše Mts. Piedmont Basin
4 Central Bohemian Basins (namely Kladno-Rakovník Basin)
5 Mšeno Part of Mšeno-Roudnice Basin
6 Plzeň Basin and Radnice Basin
7 Boskovice Graben
8 Roudnice Part of Mšeno-Roudnice Basin
9 Mnichovo Hradiště Basin

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	62	62	62	62	62
exploited	7	6	6	5	1
Total mineral *reserves, kt	16,283,583	15,217,550	16,275,710	16,272,828	16,269,450
economic explored reserves	1,460,044	1,450,481	1,441,494	1,439,817	1,400,735
economic prospected reserves	5,991,133	5,830,315	5,989,227	5,989,111	5,907,419
potentially economic reserves	8,832,406	8,836,754	8,844,989	8,843,900	8,961,296
exploitable (recoverable) reserves	22,513	29,192	15,970	3,243	1,360
Mine production, kt	4,870	4,110	3,150	1,861	2,008

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	590 300	590 300	590 300	590 300	590 300
P_2		–	–	–	–	–
P_3		–	–	–	–	–

5. Foreign trade

2701 – Bituminous coal, briquettes and similar solid fuels made of bituminous coal

		2017	2018	2019	2020	2021
Import	kt	3,729	3,475	3,577	3,426	4,573
Export	kt	2,321	1,911	1,414	767	1,395

2701 – Bituminous coal, briquettes and similar solid fuels made of bituminous coal

		2017	2018	2019	2020	2021
Average import prices	CZK/t	2,959	3,390	3,409	2,417	3,158
Average export prices	CZK/t	3,335	3,325	3,333	2,608	3,933

2704 – Coke and semi-coke from bituminous coal, brown coal or peat, agglomerated retort coal

		2017	2018	2019	2020	2021
Import	kt	228	220	221	220	241
Export	kt	744	634	589	536	652

2704 – Coke and semi-coke from bituminous coal, brown coal or peat, agglomerated retort coal

		2017	2018	2019	2020	2021
Average import prices	CZK/t	5,160	5,501	5,376	4,712	6,218
Average export prices	CZK/t	6,906	7,655	7,888	6,260	8,488

6. Prices of domestic market

OKD, a.s. bituminous coal sales

Coal type/year			2017	2018	2019	2020	2021
Coking coal	sales*	tonnes	3,479,663	5,296,946	2,286,902	1,892,812	1,059,838
	revenue	ths CZK	7,515,000	10,645,000	8,715,000	6,953,000	3,458,019
	average price	CZK/ tonne	2,160	2,010	3,811	3,673	3,263
Steam coal	sales*	tonnes	3,866,140	1,936,842	2,006,803	1,396,572	841,188
	revenue	ths CZK	5,238,000	2,790,000	4,144,000	3,104,000	2,453,174
	average price	CZK/ tonne	1,355	1,441	2,065	2,223	2,916

** saleable output*
Sources: (OKD Annual Reports)
For 2017 – OKD výroční zpráva 2017, OKD, a.s., pp. 15, 64.
For 2018 – OKD výroční zpráva 2018, OKD, a.s., pp. 10, 11.
For 2019 – OKD výroční zpráva 2019, OKD, a.s., pp. 5, 9.
For 2020 – OKD výroční zpráva 2020, OKD, a.s., pp. 11, 12.
For 2021 – OKD výroční zpráva 2021, OKD, a.s., pp. 9, 10
.

7. Mining companies in the Czech Republic as of December 31, 2021

OKD, a.s., Ostrava

8. World production and world market prices

World mine production

During 2017 and 2021, world production of bituminous coal developed as follows:

	2017	2018	2019	2020	2021[e]
Steam coal (WBD), mill t	5,531.8	5,832.3	5,960.1	5,726.3	N
Coking coal (WBD), mill t	1,022.7	1,032.2	1,055.9	1,032.0	N
Bituminous coal total (WBD), mill t	6,560.3	6,864.5	7,016.0	6,758.3	N

After Coal Information IEA 2020 production of bituminous coal reached these numbers (mill t):

	2017	2018	2019	2020	2021
Steam coal	5,726.0	6,025.0	6,175.0	5,707.0	6,200.0
Coking coal	1,000.0	978.0	1,007.0	1,015.9	1,100.0
Bituminous coal total	6,726.0	7,003.0	7,182.0	6,722.9	7,300.0

Main producers according to WBD

2020*		
Steam coal		
Country	mill t	%
China	3,005	52.5
India	671	11.7
Indonesia	558	9.7
USA	395	6.9
Australia	268	4.7
South Africa	243	4.2
Russia	241	4.2
Kazakhstan	98	1.7
Columbia	48	0.8
Poland	42	0.7
World	**5,726**	**100.0**

2020*		
Coking coal		
Country	mill t	%
China	554	53.7
Australia	184	17.8
Russia	88	8.5
USA	50	4.8
India	45	4.4
Mongolia	27	2.6
Canada	26	2.5
Poland	12	1.2
Kazakhstan	10	1.0
Ukraine	6	0.6
World	**1,032**	**100.0**

** Data 2021 not available*

Main producers according to Coal Information, IEA

2020*		
Steam coal		
Country	mill t	%
China	3,685	48.6
India	771	10.2
Indonesia	545	7.2
USA	539	7.1
Australia	476	6.3
Russia	397	5.2
Kazakhstan	108	1.4
Germany	103	1.4
Poland	98	1.3
Czech Republic	38	0.5
Other EU	70	0.9
Other countries	745	9.8
World	**7,575**	**100.0**

2020*		
Coking coal		
Country	mill t	%
China	540	53.6
Australia	175	17.4
Russia	85	8.4
USA	60	6.0
India	60	6.0
Mongolia	25	2.5
Canada	25	2.5
Poland	20	2.0
Kazakhstan	12	1.2
Indonesia	5	0.5
World	**1,007**	**100.0**

** Data 2021 not available*

EURACOAL regularly publishes data on the extent of maritime trade in bituminous coal. broken down into steam and coking coal in its Market Report:

Steam coal (mill tonnes)

Exporter	2017	2018	2019	2020	2021
Indonesia	324	343	375	342	346
Australia	200	208	212	199	198
Russia	166	172	179	169	178
Colombia	83	80	76	52	56
South Africa	83	81	78	75	66
USA	37	48	36	24	35
others	7	8	20	15	18
Total	**900**	**940**	**976**	**876**	**897**

Coking coal (mill tonnes)

Exporter	2017	2018	2019	2020	2021
Australia	177	179	183	172	167
Canada	28	30	31	31	26
USA	46	52	46	35	38
Russia	23	26	26	29	32
Total world	**28**	**291**	**290**	**266**	**266**

The world's largest importers of bituminous coal (according to China Coal Economic Research Association) (for 2017) and according to IEA (for 2018, 2019, 2020 and 2021)

Bituminous coal total (million tonnes)					
Country	**2017**	**2018**	**2019**	**2020**	**2021**
China	271	281	298	309	317
India	200	223	247	211	223
Japan	194	184	185	183	179
South Korea	148	136	130	123	121
Tchajwan	69	67	67	63	64
Germany	37	45	41	30	32
Turkey	33	38	38	40	48
Philippines	24	N	N	N	N
Thailand	22	N	N	N	N
Vietnam	14	23	44	53	62

World market prices

World prices of bituminous coal both contractual and spot. are traditionally determined mainly by prices of American and Australian coal.

EURACOAL (Market Report 2016 to 2021) provided an overview of the development of monthly prices of steam coal in USD/tce and EUR/tce CIF South-West Europe in terms of 7,000 kcal/kg

Month/year		01	02	03	04	05	06	07	08	09	10	11	12
2016	USD	56.19	52.34	53.00	52.61	54.48	59.31	62.94	71.19	71.12	88.52	100.2	100.4
2016	EUR	51.74	47.18	47.75	46.40	48.17	52.82	56.86	63.49	63.43	80.28	92.83	95.24
2017	USD	101.1	97.64	91.16	90.50	85.93	90.25	97.81	97.79	103.1	107.3	110.8	107.2
2017	EUR	95.30	91.75	85.33	84.41	77.72	80.38	84.98	82.83	86.50	91.30	94.36	90.61
2018	USD	112.23	105.54	94.21	93.45	99.75	110.58	116.55	110.28	117.41	118.35	113.97	100.42
2018	EUR	92.01	85.47	76.37	76.13	84.45	94.69	99.80	95.50	100.71	103.06	100.27	88.20
2019	USD	98.40	92.17	87.38	63.71	67.78	59.05	62.43	68.50	66.22	69.81	65.52	64.86
2019	EUR	86.19	81.20	77.32	56.69	60.61	52.28	55.65	61.56	60.18	63.17	59.29	58.36
2020	USD	60.76	56.91	55.14	56.14	44.64	53.63	59.16	60.06	60.40	66.90	59.97	72.35
2020	EUR	54.74	52.19	49.85	51.69	40.95	47.65	51.62	50.78	51.22	56.81	50.66	59.45
2021	USD	80.47	75.69	77.42	81.61	94.43	115.47	142.16	166.76	189.12	250.29	174.74	141.54
2021	EUR	66.12	62.57	65.07	68.12	77.72	95.81	120.22	141.67	160.67	215.75	153.11	125.22

BP Statistical Review of World Energy (BP) and the World Bank – The Pink Sheet (WB) report average prices of some types of coal (USD/t – BP. resp. USD/mt – WB)

Year	2017	2018	2019	2020	2021
Market price in NW Europe (BP)	84.51	91.83	60.86	50.16	121.70
Spot prices of the US Central Appalachian coal (BP)	63.83	72.84	57.16	42.77	68.54
The spot price of Japanese imports (BP)	99.16	117.39	108.58	80.50	130.37
Coking coal CIF (BP)	94.72	99.45	85.89	83.10	153.55
Spot price of coal. China. Qinhangdao (BP)	88.52	107.02	77.89	60.80	138.10
Australian steam coal. 6.300kcal CIF Neawcastle (WB)	77.80	N	N	N	N
Colombian coal (WB)	85.15	97.64	71.94	65.70	119.80
South African coal (WB)	63.95	85.15	97.64	71.94	65.66

Brown coal

1. Characteristics and use

Brown coal (lignite, subbituminous coal) is a phytogenic kaustobiolite coalified less than bituminous coal. The boundary between brown and bituminous coal is not internationally exactly defined, but its definition given by the value of combustion heat on an anhydrous ashless basis (Q sm,af) < 24 MJ/kg and light reflectance of vitrinite Rr < 0.6% is generally accepted. The most coalified brown coal (in Czech terminology brown coal metatype) is called subbituminous coal in foreign literature.

The international boundary between brown coal and lignite has not been established, but lignite is usually considered to be a raw material with a carbon content in combustibles below about 65% and a calorific value <17 MJ/kg. The terminology of coal is not uniform around the world, often the English term "lignite" is used to denote both the quality of our (Central European) brown coal and of lignite (brown coal hemitype), which is reported separately in the Czech Republic.

Reserves

2021		
Country	**mill t**	**% world**
Russia	90,447	28.2
Australia	76,508	23.9
Germany	35,900	11.2
USA	30,003	9.4
Indonesia	11,728	3.7
Turkey	10,975	3.4
China	8,128	2.5
Serbia	7,112	2.2
New Zealand	6,750	2.1
Poland	5,865	1.8
World	**320,469**	**100.0**

2021			
Country	**mill t**	**% world**	**% EU**
EU	53,051	16.6	100.0
Germany	35,900	11.2	67.7
Poland	5,865	1.8	11.1
Greece	2,876	0.9	5.4
Hungary	2,633	0.8	5.0
Bulgaria	2,174	0.7	4.1
Czechia	1,081	0.3	2.0
Spain	319	0.1	0.6
Romania	280	0.09	0.5

Source: BP Statistical Review of World Energy 2022 (no update on 2021 reserves).

Uses

The use of brown coal is mainly in the energy industry (electricity and heat production), to a lesser extent in the chemical industry.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

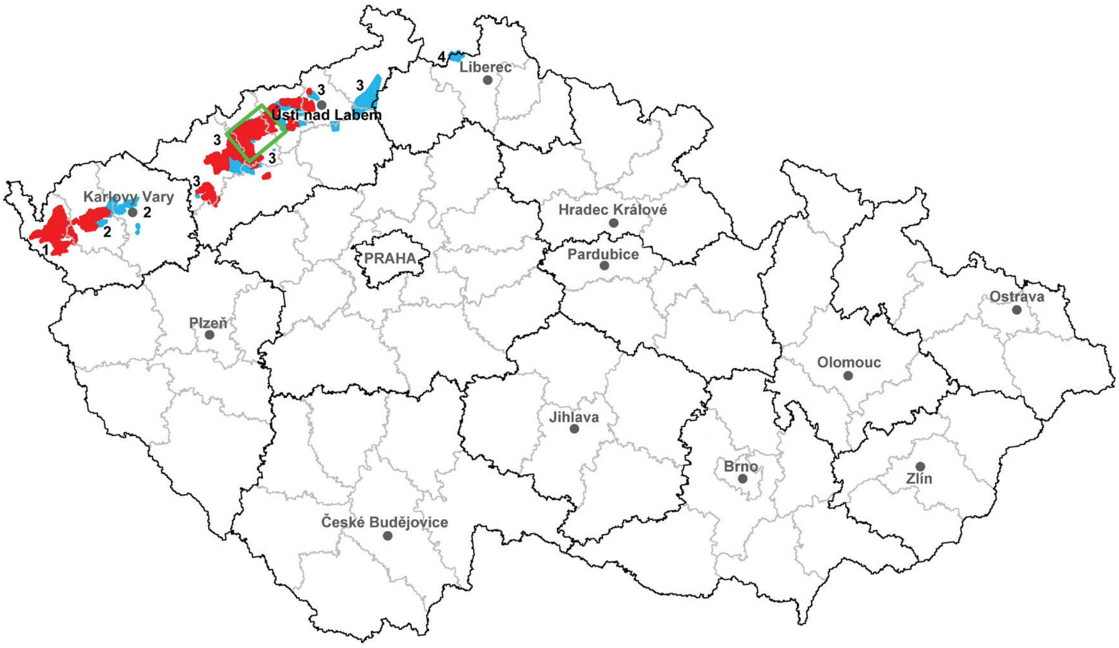
Brown coal is still the main source of energy in the Czech Republic. The largest Czech brown coal basins originated in a tectonic trough and follow the direction parallel to the Ore Mountains and the northwestern border of the Czech Republic. The total area of coal-bearing sedimentation is 1,900 km^2. The underlying sediments are classified into the Eocene, the seams and overlying sediments (up to 400 m thick) belong to the Lower Miocene, and in the Cheb Basin, the sedimentation ends as far as in the Pliocene. In the area of the basins at the foothills of the Ore Mountains (Podkrušnohorská basins), the following main separate basins are mostly defined (from NE to SW): North Bohemian, Sokolov and Cheb. The largest North Bohemian Basin is further divided into 3 parts. The North Bohemian Basin accounts for about 80% of the total brown coal production in the Czech Republic, the remaining 20% comes from the Sokolov Basin. Mining is practically exclusively surface.

- In the Chomutov part of the North Bohemian Basin, the brown coal seam is divided into 3 benches. Towards the NW of the basin, these layers are joined or converged and are surface mined together. This coal has less calorific energy and lower to medium degree of coalification. It is used mainly for combustion in power plants, the desulphurisation of which has eliminated the problem of increased sulphur content (S^d around 2.8%) in this coal. The ash content generally rises from NW to SE, where it can reach up to 50% (on average it is around 35-40%). The average thickness of the mined seam is about 23 m and the calorific value of coal Q_i^r is about 10 MJ/kg. Coal from this part of the basin is mined by one large quarry Tušimice-Libouš (mining lease Tušimice).
- Coal with a lower ash content (15–40%) and a higher degree of coalification is mined in the Most part of the North Bohemian Basin. Coal is used in the energy sector, and sorted types are also produced for small consumers. It has locally significantly increased contents of sulphur (Sd usually between 1 and 1.5%) and arsenic. The average thickness of the mined seam is between 20–30 m, the calorific value between Qir 10–17 MJ/kg. The depth of surface mining is gradually increasing, currently reaching up to 150 m in some places. Mining in this part of the basin is provided by 4 large quarries: Bílina-Velkolom Bílina, Ervěnice-Velkolom ČSA, Holešice and Komořany (mining areas Bílina, Ervěnice, Holešice, Komořany u Mostu). The quarries with the highest lifetime period are Holešice, Bílina-Velkolom Bílina. The Vršany and Slatinice quarries, which are connected to the Holešice quarry, are set aside for reserve and the planned continuation of mining. In the last deep mine Dolní Jiřetín-Centrum (mining area Dolní Jiřetín u Mostu), mining was finished in the first quarter of 2016. Experimental underground mining was started, so called corridor mining, where small amounts of coal were extracted from the closing slopes of the quarry (Komořany, Ervěnice). At present, this method of mining is no longer practiced. The complex hydraulic, forestry and agricultural reclamation was also completed as part of the revitalisation of the area after the Most – Ležáky quarry, where coal mining was definitively terminated on 31 August 1999.
- In the Teplice part of the North Bohemian Basin, mining ended in 1997 with the closure of the Chabařovice quarry. The remaining reserves of medium-coalified, high-quality coal with a low sulphur content below the municipality of Chabařovice will not be possible to extract due to conflicts of interest and complex hydrogeological conditions. Similar conflicts will probably prevent the extraction of other reserves of quality coal in other sections of this

part of the basin. Small isolated occurrences of brown coal seams in the Central Bohemian Uplands were largely mined in the past.

- The Sokolov Basin west of Karlovy Vary has two main seam formations (Antonín and Josef). The largest reserves are contained in the thickets and highest seam Antonín, in the western part divided into 2 to 3 benches. It is a weakly to moderately coalified steam coal with a lower sulphur content (S^d around 1%) and a higher water content compared to the coal of the North Bohemian Basin. Since 2001, mining has been taking place only in the east of the central part of the basin. A seam with an average mined thickness of 26–38 m is surface mined in the Alberov-Velkolom Jiří large quarry (Alberov mining lease). Since 2015, only overburden works have been carried out in the Nové Sedlo-Družba quarry (mining lease Nové Sedlo) and no coal has been mined. Smaller coal mining took place until 2017 in the Královské Poříčí-Marie quarry (mining lease Královské Poříčí). Since 2012, the coal of potentially economic reserves has been mined and recovered to a small extent during remediation work in the western part of the basin in the northern part of the Svatava-Medard quarry (Svatava mining lease). The calorific value Q_i^r is between 12 and 14 MJ/kg and the ash content A^d is between 20 and 24%. Coal is used mainly in the energy industry (sorted fuels, combustion in power plants and production of energy gas and briquettes), but also in the production of some carbochemical products. The coal of the lower Josef seam, which had a higher degree of coalification, but also increased contents of ash, Ge, sulphur and other pollutants (As, Be), is no longer used. In the past, it was mined in smaller quantities in isolated relics south of Karlovy Vary.
- The Cheb Basin has over 1.7 billion tonnes of geological reserves of weakly coalified brown coal (calorific value Q_i^r around 10 MJ/kg). The coal has an increased content of water, ash (20–40 %), sulphur (2–4 %) and other pollutants. Due to the locally high content of liptodetrites, it could also be suitable for chemical processing. In the past, it was mined for a short time, especially in the Pochlovice part of the basin to the East. However, re-mining of coal in this basin is still impossible, the vast majority of reserves are tied to the protection of mineral water resources Františkovy Lázně.
- From Germany and especially Poland, a small part of the Zittau Basin extends into the Czech Republic. The upper seam has already been mined on the surface, the deep mining of the remaining two seam horizons is hindered not only by economic but also technical problems with the amount of waterlogged sands in the overburden.
- In the past, small occurrences of low-quality brown coal in the Czech Cretaceous basin were occasionally mined in small quantities as an accompanying raw material in the mining of refractory clays, e.g. near Moravská Třebová or Svitavy.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits

exhausted deposits and other resources

area of ecological territorial limits for mining (Government Resolution no. 444/1991)

Coal basin

(Names of basins with mined deposits are indicated in ***bold type****)*

1 Cheb Basin

2 **Sokolov Basin**

3 **North–Bohemian Basin**

4 Czech part of the Zittau (Žitava) Basin

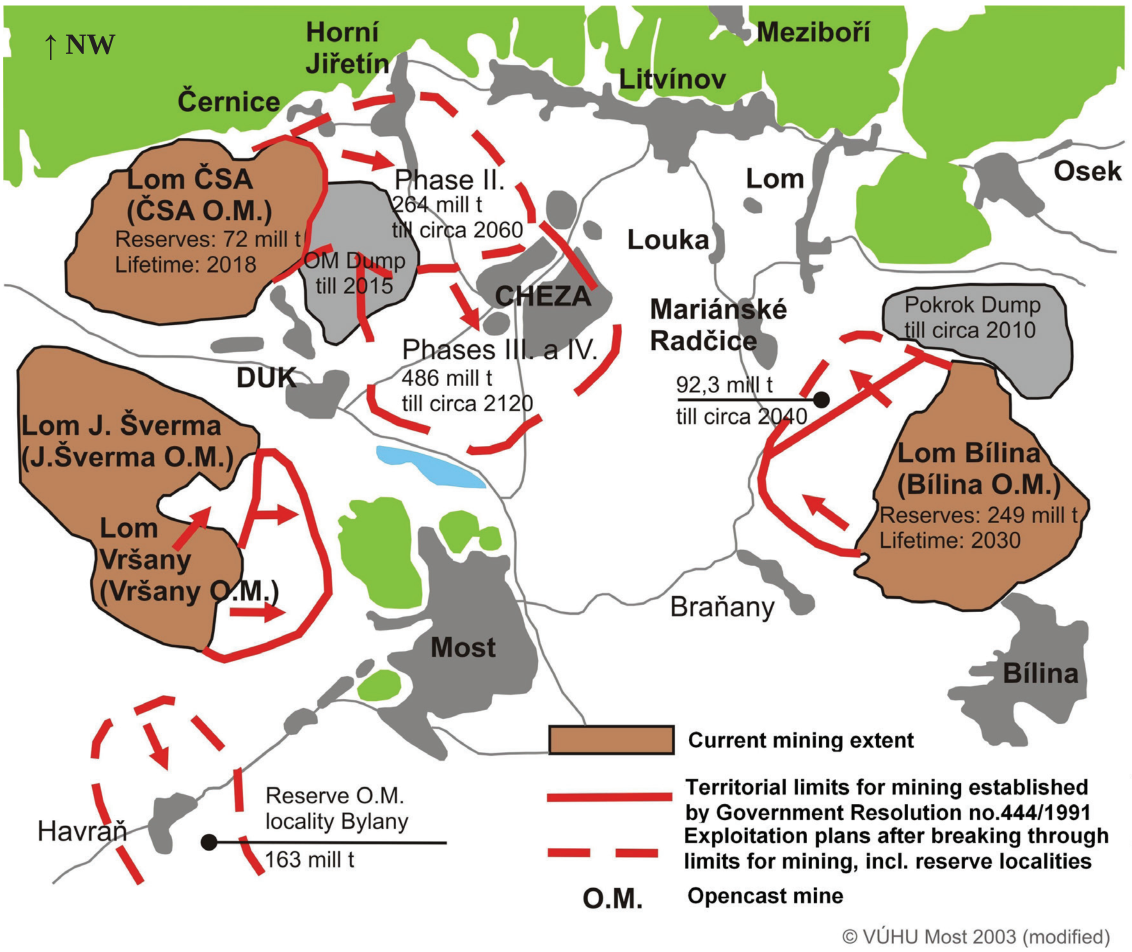
Territorial ecological mining limits

Josef Godány

The relatively large reserves of brown coal in Northern Bohemia (North Bohemian coal basin) are blocked by “Regional environmental limits” for brown coal mining in Northern Bohemia (today this relates only to the North Bohemian coal basin). The limits were set by Czech Government Resolutions Nos. 166, 443, and 490 of 1991 (for the Sokolov coal basin) and Resolution No. 444 of the same year (for the North Bohemian coal basin). The Government Resolutions define mining areas which should remain unexcavated. The main reason for setting the limits was environmental and landscape protection of Northern Bohemia. However, territorial limits for the Sokolov coal basin were removed relatively soon – by Government Decree No. 511 of 1993.

With diminishing reserves of brown coal in mined areas there is an escalating pressure to reconsider or amend the original decision of 1991, i.e. the preserved Government Resolution No. 444/1991. There was a minor change to the territorial environmental limits in the foreground of the large opencast mine Bílina (deposit in Bílina) by Government Resolution No. 1176/2008 and the subsequent Government Resolution No. 827/2015 which repealed Government Resolution No. 1176/2008 and significantly moved the environmental limit boundary – to the distance of 500 m from the urban area of Mariánské Radčice. This shifted the anticipated end of mining in the mine from 2038 to 2055. The mining company has been ordered to primarily use the mined coal to meet the needs of the heating industry. Government Resolution No. 444/1991 still applies to the remaining deposit area, including the large opencast mine ČSA (deposit in Ervěnice – ČSA mine). The question of breaking the territorial environmental limits in the ČSA opencast mine will remain conditionally open until 2020 (if the current territorial environmental limits are preserved, the mining is expected to end in 2024). The coal reserves behind the territorial environmental limits in the ČSA opencast mine are of the highest quality (the calorific value of coal from this deposit area is at least 17 MJ/kg).

Overall, the environmental territorial limits block about 954 million tonnes of coal reserves. The truth is that brown coal and nuclear power are still the only relevant sources for our energy sector. Brown coal is also the most important raw material for the Czech heating industry. The main product of the brown coal industry is a dusty brown coal for power stations and heating plants. In the long term, approximately 93 % of brown coal produced is consumed by these facilities. Graded coal production for households accounts for the remaining 7 %.



4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	52	52	52	52	52
exploited	10	10	10	10	7
Total mineral* reserves, kt	8,673,268	8,633,149	8,595,438	8,565,403	8,538,637
economic explored reserves	2,210,477	2,173,864	2,138,948	2,111,604	2,086,805
economic prospected reserves	2,059,859	2,059,859	2,059,859	2,059,854	2,059,854
potentially economic reserves	4,402,932	4,399,426	4,396,631	4,393,945	4,391,978
exploitable (recoverable) reserves	681,540	646,528	612,729	586,457	562,735
Mine production, kt	39,310	39,187	37,465	29,505	29,278

Notes:
** See NOTE in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

5. Foreign trade

2702 – Brown coal, also agglomerated, except jet

		2017	2018	2019	2020	2021
Import	kt	331	340	246	183	185
Export	kt	987	918	728	549	437

2702 – Brown coal, also agglomerated, except jet

		2017	2018	2019	2020	2021
Average import prices	CZK/t	1,938	1,844	2,170	2,346	2,473
Average export prices	CZK/t	1,621	1,694	1,764	1,864	1,846

Note: Jet is a compact black variety of brown coal used in (mourning) jewelry

6. Prices of domestic market

Domestic brown coal prices*

Product specification	2017	2018	2019	2020	2021
graded; cube coal II; 17.6 MJ/kg; Severočeské doly	2,200	2,250	2,475	2,475	2,575
graded; nut coal I; 17.6 MJ/kg; Severočeské doly	2,020	2,125	2,340	2,360	2,485
graded; nut coal II; 17.6 MJ/kg; Severočeské doly	2,070	2,090	2,290	2,340	2,555
coarse coal dust I, II; Severočeské doly; 16.9 MJ/kg	N	N	N	N	N
industrial mixture; 10.5–15.6 MJ/kg; Severočeské doly	N	N	N	N	N

** Prices given without taxes on solid fuels.*

Sokolovská uhelná Company has not been producing graded coal since 2009. Mostecká uhelná Company has been selling the coal in auctions, price lists will no longer be issued.

7. Mining companies in the Czech Republic as of December 31, 2021

Severočeské doly, a.s., Chomutov
Vršanská uhelná a.s., Most
Sokolovská uhelná, právní nástupce, a.s., Sokolov
Severní energetická a.s., Most

8. World production and world market prices

World mine production

In the five-year period 2017–2021, world production of brown coal developed as follows:

	2017	2018	2019	2020	2021e
Brown coal and lignite (WBD), mill t	822.7	803.1	738.3	636.1	N
Brown coal and lignite (IEA), mill t	826.0	801.0	739.0	638.5	N

e – preliminary values

Main producers according to WBD 2021

2020		
Country	**mill t**	**%**
Germany	107.4	16.9
Russia	72.6	11.4
Turkey	71.2	11.2
Poland	47.3	7.4
USA	44.8	7.0
Australia	41.5	6.5
Serbia	39.7	6.2
India	36.6	5.8
Czech Republic	29.5	4.6
Bulgaria	22.5	3.5
World	**636.1**	**100.0**

Market and prices

Brown coal is subject to world trade to a limited extent only. Compared to the trade with bituminous coal, brown coal does not pay off when being transported over long distances. Therefore, trade mainly takes place between neighbouring countries on the basis of contract prices that are not available in the published statistics.

Crude oil

1. Characteristics and use

Crude oil is a natural mixture of liquid, solid and gaseous compounds, mainly hydrocarbons. Its specific gravity varies between 0.75 and 1 t/m^3, the average carbon content between 80 and 87.5%, the hydrogen content between 10 and 15% and the calorific value between 38 and 42 MJ/kg. The source of hydrocarbons is organic matter formed by subaquatic biochemical decomposition of dead biomass. Oil formation occurs at temperatures of 60–140 °C, at depths of 1,300–5,000 m in pelitic oil-bearing sediments. From there it migrates and accumulates in permeable, porous or cracked collector rocks. Extracted oil is referred to as crude oil and has highly variable properties such as colour, viscosity, molecular weight and specific gravity.

Crude oil is classified as light, medium or heavy according to its specific gravity measured on the API gravity scale. At 60° F (15.6 °C), light oil has a specific gravity below 31.1 °API, medium-heavy oil has a specific gravity between 22.3–31.1 °API, heavy below 22.3 °API.

According to the chemical composition, there are 4 basic types – paraffinic, naphthenic, aromatic and asphaltic oil.

Crude oil is also referred to as sweet or sour according to the sulphur content (sweet below 0.5 wt.% S, acidic above this limit).

Industrially important deposit types

Until the 1990s, oil extraction, with one exception, was carried out by drilling from deposits of its secondary accumulation. The exception were tar or bituminous sands which were mined. Since the 1990s, the USA has developed the extraction of shale oil (and shale gas) from primary deposits by drilling using hydraulic fracturing – fracking of oil-bearing parent rocks.

Bituminous sands are a promising source. The world's largest deposits and resources are located in Venezuela (Orinoco slate sands) and Canada (Athabasca slate sands). Due to the economic and technical complexity of extraction, they are currently mined in large quantities only in Canada by surface mining. The bitumen content (8–14 °API) in sands is usually between 10–12%. The extracted bitumen is processed into synthetic crude oil or directly into petroleum products in specialised refineries

Uses

Crude oil is usually treated by distillation (refining) to separate its individual fractions: gasoline, petrol, kerosene, diesel, lubricating oil, asphalt. Higher hydrocarbons (long hydrocarbon chains) are treated (shortened) in the cracking process. The use of oil is versatile, new possibilities are constantly emerging. The largest volume of consumption is used for energy in transport systems, the energy industry in general, and in the petrochemical (supplying transport) and chemical industries.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

Reserves

2020		
Country	**Bn tonnes**	**% world**
Venezuela	48.0	19.6
Saudi Arabia	40.9	16.7
Canada	27.1	11.1
Iran	21.7	8.9
Iraq	19.6	8.0
Russia	14.8	6.1
Kuwait	14.0	5.7
United Arab Emirates	13.0	5.3
World	**244.4**	**100.0**

2020			
Country	**Bn tonnes**	**% world**	**% EU**
EU	0.3	0.12	100.0
Romania	0.1	0.04	33.3
Denmark	0.1	0.04	33.3
Italy	0.1	0.04	33.3

Source: BP Statistical Review of World Energy 2022 (dates for 2021 are not listed)

The USA has a share of world reserves mere 3%. About 40% of this 3% is shale oil (U.S. Crude oil and natural gas proved reserves, year-end 2018. – U.S. Geological Survey fact sheet 2009–2028).

2. Mineral resources of the Czech Republic

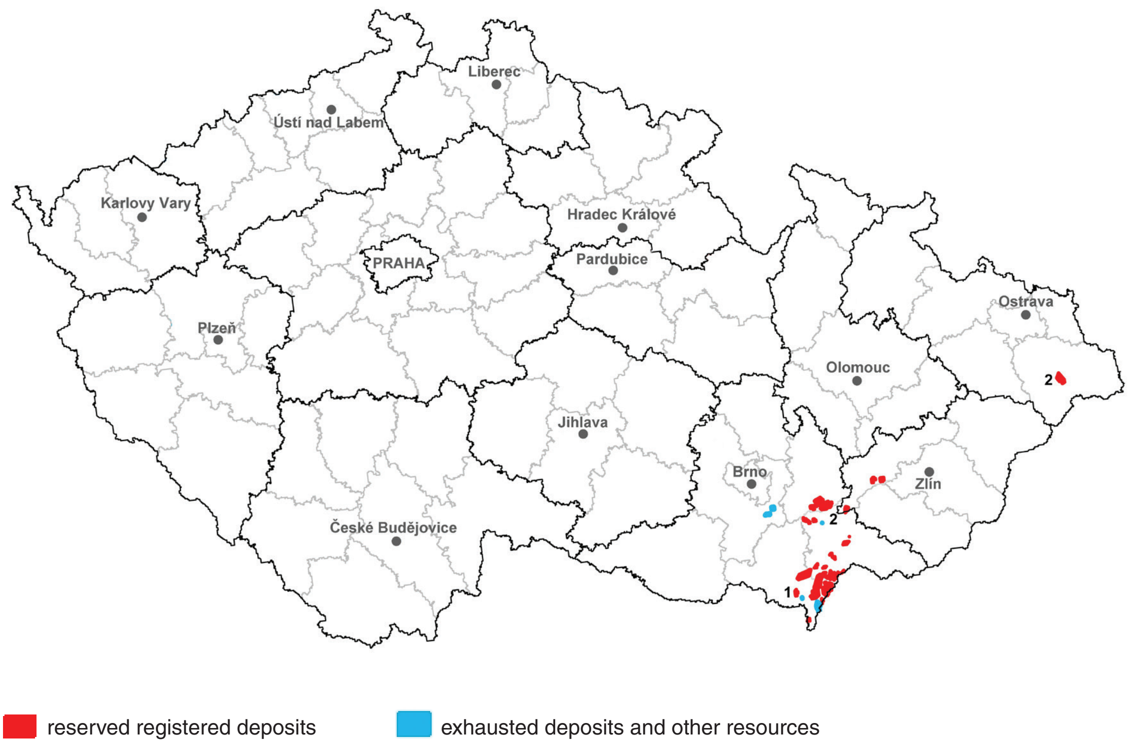
Unlike coal, the Czech Republic does not have sufficient resources for oil or natural gas. Industrially significant oil accumulations occur mainly in southern Moravia and are linked to the geological units of the Western Carpathians and the SE slopes of the Bohemian Massif. Although domestic oil production grew until 2003 and has been relatively stable in recent years, it covers only about 2–3% of domestic needs.

- In the area of the Vienna Basin (Moravian part), the deposits are scattered into many substructures and productive horizons, lying mainly at depths from 450 to 2,000 metres. The most productive are the sandstones of the middle and upper Baden. The largest in this area is the Hrušky deposit, most of which has already been extracted. However, research in the area is still ongoing. New oil fields with a gas cap have been discovered and are being extracted in the Poštorná, Poddvorov and Prušánky areas.
- The area of the Carpathian foredeep and SE slopes of the Bohemian Massif. The deposits found so far are among the largest oil deposits in the Czech Republic. The most significant accumulations are mainly related to collectors in the Miocene, Jurassic and to cracked and weathered parts of the crystalline complex. Dambořice currently remain the largest and most important oil deposit. Other important deposits Borkovany, Žarošice, Uhřice and Ždánice were discovered in the vicinity of this deposit by a systematic survey conducted on the basis of interpretation of 3D seismic data. Oil is accumulated here in Jurassic sediments – at the Žarošice deposit in the Vranovice carbonates and at the Uhřice-jih deposit in the sandstones of the Gresten Formation. At present, these deposits are intensively extracted – they account

for about 70% of the total oil production in the Czech Republic and almost 80% of the recoverable reserves. In order to achieve the highest possible yield, the technology of horizontal wells is also used in extraction. In the case of the Uhřice-jih and Dambořice deposits, gas is additionally injected into the top parts of the deposits in order to maintain the deposit pressure. At the Žarošice deposit, a significant source of pressure is present in the form of the gas cap and the active bedding water, and therefore the use of this method is not yet necessary.

Oil and gas deposits are genetically linked. In the Vienna Basin, oil deposits occur in Baden and Lower Miocene sediments, while in the Sarmatian, only gas deposits are found. Crude oil in the Czech Republic is mostly light, sulphur-free, paraffinic to paraffinic-naphthenic. In 2009, 3 types of crude oil were mined in the Czech Republic – light, medium and heavy, with specific weights from 812 to 930 kg/m^3 at 20 °C, which corresponds to 20 to 43°API, sulphur contents in the crude oil ranged from 0.08 to 0.32 % of weight.

3. Registered deposits and other resources of the Czech Republic



Principal areas of deposits presence

*(names of areas with exploited deposits are indicated in **bold type**)*

1 **Vienna Basin**	2 **West–Carpathian Foredeep**

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	39	39	39	39	39
exploited	33	33	33	34	32
Total mineral *reserves, kt	30,546	31,562	31,482	31,391	31,308
economic explored reserves	21,386	21,720	21,648	21,565	21,491
economic prospected reserves	3,345	4,027	4,020	3,963	4,004
potentially economic reserves	5,815	5,815	5,814	5,863	5,813
exploitable (recoverable) reserves	1,401	1,575	1,439	1,361	1,359
Mine production, kt	107	109	81	91	83

** See NOTE in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

5. Foreign trade

2709 – Petroleum oils and oils obtained from bituminous minerals, crude

		2017	2018	2019	2020	2021
Import	kt	7,814	7,439	7,738	6,174	6,841
Export	kt	24	22	0.2	0.4	0.001

2709 – Petroleum oils and oils obtained from bituminous minerals, crude

		2017	2018	2019	2020	2021
Average import prices	CZK/t	9,498	11,644	11,094	7,970	11,404
Average export prices	CZK/t	8,870	10,594	9,833	468,835	235,562

271011 – Petrol (Gasoline)

		2017	2018	2019	2020	2021
Import	kt	N	N	N	N	N
Export	kt	N	N	N	N	N

271011 – Petrol (Gasoline)

		2017	2018	2019	2020	2021
Average import prices	CZK/t	N	N	N	N	N
Average export prices	CZK/t	N	N	N	N	N

Czech Republic crude oil import by country and import costs

	2017		2018		2019		2020		2021	
Country	**kt**	**CZK/t**	**kt**	**CZK/t**	**kt**	**CZK/t**	**kt**	**CZK/t**	**kt**	**CZK/t**
Russia	4,100	9,156	4,003	11,143	3, 821	10,585	3,013	7,337	3,417	11,089
Azerbaijan	2,425	9,789	2,183	12,241	2,194	11,662	1,426	8,968	1,096	11,958
USA	–	–	–	–	277	11,395	728	7,990	804	11,422
Kazakhstan	986	9,949	986	12 468	990	11,827	567	10,041	1,239	11,676
United Kingdom	–	–	–	–	–	–	128	7,811	1	N
Saudi Arabia	178	10,391	98	11,075	104	10,612	104	3,515	1	N
Norway	–	–	–	–	–	–	89	7,034	81	14,390
Nigeria	–	–	–	–	178	11,228	59	6,424	45	6,512
Niger	–	–	–	–	–	–	35	6,622	N	N
Algeria	76	9,991	82	10,773	82	9,816	26	7,967	N	N
Total	**7,812**	**9,498**	**7,439**	**11,644**	**7,738**	**11,093**	**6,175**	**11,940**	**6,684**	**11,174**

Note: Only countries with imports exceeding 10 tonnes of crude oil in a given year are included
Source: ČSÚ

6. Prices of domestic market

Prices of domestic producers are not open to public.

7. Mining companies in the Czech Republic as of December 31, 2021

MND a.s., Hodonín
LAMA GAS & OIL s.r.o., Hodonín

8. World production and world market prices

World production

World crude oil production reached these amounts in recent years:

	2017	2018	2019	2020	2021
World crude oil production (WBD), mill t	4,368.8	4,466.4	4,471.0	4,175.5	N
World crude oil production (BP), mill t	4,386.4	4,486.8	4,477.6	4,170.9	4,221.4

Note: BP – BP Statistical Review of World Energy. 2021

Main producers according to BP

2021		
Country	**mil.t**	**%**
USA	711	16.8
Russia	536	12.7
Saudi Arabia	515	12.2
Canada	267	6.3
Iraq	201	4.8
China	199	4.7
United Arab Emirates	164	3.9
Iran	168	3.7
Brazil	157	4.0
Kuwait	131	3.1
World	**4,171**	**100**

World market prices

The price development of the OPEC basket oil according to EURACOAL (Market Report):

Month/ year	01	02	03	04	05	06	07	08	09	10	11	12
2016	26.50	28.72	34.65	37.86	43.21	45.84	42.68	43.10	42.89	47.87	43.22	51.67
2017	52.40	53.37	50.32	51.37	49.20	45.21	46.93	49.60	53.44	54.90	60.74	62.06
2018	66.85	63.48	63.76	68.43	74.11	73.22	73.27	72.26	77.18	79.39	65.33	56.94
2019	58.74	63.83	66.37	70.78	69.97	62.92	64.71	59.62	62.36	59.91	62.94	66.48
2020	65.10	55.53	33.92	17.66	25.17	37.05	43.42	45.19	41.54	40.08	42.61	49.17
2021	54.38	61.05	64.56	63.24	66.91	71.89	73.53	70.33	73.88	82.11	80.37	74.38

The average price quotations of crude oil purchases according to the IEA and BP

Commodity/Year	Units	Conversion factor	2017	2018	2019	2020	2021
Brent Crude, CIF Rotterdam	USD/bbl	1 t = 7.560 bbl	54.19	71.31	64.21	41.84	70.91
	USD/t		409.68	539.10	485.43	316.31	53.08
Dubai Crude, CIF Rotterdam	USD/bbl	1 t = 7.596 bbl	53.02	70.15	63.71	42.41	68.91
	USD/t		402.74	532.86	483.94	322.15	523.44
West Texas Intermediate (WTI), CIF Rotterdam	USD/bbl	1 t = 7.400 bbl	50.79	65.20	57.03	39.25	68.10
	USD/t		375.85	482.48	422.02	290.45	503.94
Nigerian Forcados Crude, CIF Rotterdam	USD/bbl	1 t = 7.500 bbl	54.31	72.47	64.95	42.31	69.76
	USD/t		407.33	543.53	487.13	317.33	523.20
OPEC basket, CIF Rotterdam	USD/bbl	1 t = 7.090 bbl	52.40	68.90	63.18	42.17	68.24
	USD/t		371.52	488.50	447.95	298.99	483.82

Note: bbl = abbreviation of term barrel

Natural gas

1. Characteristics and use

Natural gas is a mixture of gaseous hydrocarbons, especially methane (CH_4), and other gases (hydrogen, nitrogen, carbon dioxide, hydrogen sulphide and inert gases). Methane predominates – more than 50% of the mixture. Raw gas has a certain admixture of oil, water and sand. In the Czech Republic, there are 3 basic types of natural gas: dry gas (with CH_4 content 98–99%), moist gas (85–95% CH_4 and hydrocarbon admixture) and gas with an increased proportion of inert components (50–65% CH_4, over 10% N_2 and over 20% CO_2).

There are two types of natural gas: conventional, more or less oil related, and unconventional. Unconventional types of natural gas differ by their sources and they include tight gas. i.e. gas retained in impermeable or only partially permeable sandstones (tight gas, tight sandstones), shale gas, i.e. gas retained in shale, gas hydrate in sediments of seabeds or permanently frozen polar soil (permafrost), coal bed methane (CBM). Coal bed methane is unconventional only where it is extracted from seams by drilling and artificial cracking of coal. Methane obtained from degassing wells or shafts in connection with coal mining is referred to as coal mine methane (CMM) and it is not considered an unconventional type of natural gas.

Industrially important deposit types

Until the 1990s, natural gas was extracted from conventional deposits. Since the 1990s, the USA has developed the extraction from unconventional deposits – deposits of shale oil (and shale gas) – by drilling using hydraulic fracturing – fracking of oil-bearing and gas-bearing parent rocks.

Reserves

2021		
Country	**Trillion m^3**	**% world**
Russia	37.4	19.9
Iran	32.1	17.1
Quatar	24.7	13.1
Turkmenistán	13.6	7.2
USA	12.6	6.7
China	8.4	4.5
Venezuela	6.3	3.3
Saudi Arabia	6.0	3.2
United Arab Emirates	5.9	3.1
World	**188.1**	**100.0**

2021			
Country	**Trillion m^3**	**% world**	**% EU**
EU	0.3	0.16	100.0
Netherlands	0.1	0.05	33.3
Poland	0.1	0.05	33.3
Romania	0.1	0.05	33.3

Source: BP Statistical Review of World Energy 2022

Uses
Natural gas, along with oil and coal, is one of the world's major natural fuels. It is a versatile source of energy – it is most often used for heating and electricity generation.

Classification as critical raw materials for the European Union:
2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

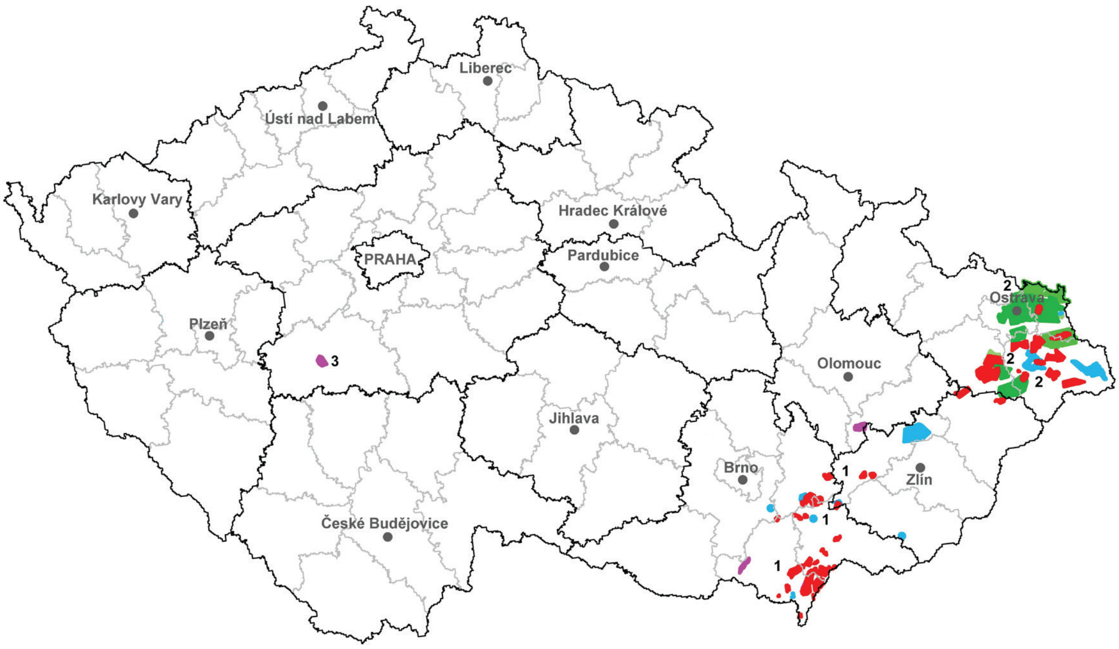
As in the case of oil, the Czech Republic does not have sufficient sources of natural gas. Deposits and resources are concentrated in southern and northern Moravia. They are connected to the geological units of the Western Carpathians and the south-eastern slopes of the Bohemian Massif, where they are mostly connected with oil. In northern Moravia, they are also bound to the coal seams of the Upper Silesian Basin. Natural gas production in the Czech Republic has been relatively stable for a long time and covers about 1 to 2% of domestic consumption.

- Natural gas deposits, genetically linked to the formation of oil, are found in the Moravian part of the Vienna Basin. Oil deposits are concentrated mainly in the central part of the basin, gas deposits predominate in the peripheral areas. They are deposited in Baden sediments together with oil deposits either as separate natural gas deposits or as gas caps of oil deposits or as gas dissolved in oil. The overlying Sarmatian sediments contain almost exclusively natural gas deposits. The extracted gas contains from 87.2 to 98.8% of CH_4 by volume, it has a calorific value of 35.6 to 37.7 MJ/m^3 (dry gas at 0°C), specific gravity 0.72 to 0.85 kg/m^3 (at 0°C) and H_2S content below 1 mg/m^3. New sources of natural gas were prospected especially in the area of Břeclav, Poštorná, Charvátská Nová Ves, Prušánky, Josefov, Lednice, Poddvorov, Dolní Bojanovice and Podivín, mostly using 3D seismic technology. Further research after these positive results will focus on analogous types of deposit structures. The largest exhausted natural gas deposits from the Hrušky and Poddvorov mining fields were used as underground gas storage facilities in Tvrdonice and Dolní Bojanovice.
- The area of the Carpathian foredeep and SE slopes of the Bohemian Massif is considered to be a promising area, where the most significant accumulations of natural gas are currently available. The largest deposits found so far include Dambořice, Ždánice, Dolní Dunajovice, Uhřice and Horní Žukov (gas deposits after extraction mostly converged to underground reservoirs) and Lubná-Kostelany (almost exhausted today). The most important accumulations are mainly related to trap rocks in the Miocene, Jurassic and in cracked and weathered parts of the crystalline complex. Natural gas (and gas condensate) was extracted from a depth of over 3,900 m from the deepest used Karlín deposit. These gas deposits have a very variable composition. Methane represents 98% of the Dolní Dunajovice deposit, while in the Kostelany-západ deposit, it is only 70% methane with industrially usable concentrations of He and Ar. Significant reserves are tied up in the gas caps of the Ždánice-miocén and Kloboučky heavy oil deposits. An intensive search for a new extraction technology is currently underway, which would make it possible to economically extract not only part of the reserves of heavy oil, but also natural gas bound in gas caps. A survey (especially using 3D seismic technology) discovered new resources of natural gas, especially in the Poštorná area. Based on these positive results, further research will focus on analogous types of deposit structures. The Dolní Dunajovice and

Uhřice natural gas deposits are secondarily used as underground gas storage facilities. In northern Moravia, between Příbor and Český Těšín, there are gas deposits bound mostly to weathered and tectonically disturbed carbon relief, or to directly adjacent Miocene clasts. The origin of the gas of these deposits, formed at the peaks of morphological elevations of carbon, has not yet been clearly clarified (whether it is gas formed during coalification of coal seams or gas associated with the formation of oil). These are especially the Bruzovice and Příbor deposits. Part of the Příbor deposit or the already mined-out Žukov deposit serve as an underground gas storage.

- Demonstrably Carboniferous gas is obtained by degasification (mining from already closed deep mines) of coal seams of the Czech part of the Upper Silesian coal basin. During this process, the mine gases are diluted by air suction and the resulting concentration of the gases thus obtained is around 50–55% CH_4; O_2, N_2, CO and CO_2 are also present. Its quality depends on the methods and technical possibilities of this degasification and it is therefore very volatile. CH_4 content of the undiluted carbon dioxide is 94 to 95%. Gas from individual locations is supplied for consumption to local customers (e.g. Mittal Steel) through a network of more than 100 km long pipelines. Natural gas sorbed on coal seams accounts for about 22–25% of the current total production and recoverable reserves in the Czech Republic. Natural gas from the Rychvald deposit is transported by a 22 km long gas pipeline to the Nová Huť steelworks in Ostrava.
- Numerous occurrences of natural hydrocarbons both on the surface and in the boreholes were found in the area of the Carpathian flysch mantles. In the past, there was limited mining from several deposits (e.g. Hluk).

3. Registered deposits and other resources of the Czech Republic



- reserved registered deposits of natural gas
- exhausted deposits and other resources of natural gas
- reserved registered deposits of natural gas adsorbed on coal seams
- other resources of natural gas adsorbed on coal seams
- underground gas reservoirs

Principal areas of deposits and underground gas reservoirs

*(Names of regions with mined deposits are indicated in **bold type**)*

1 **South-Moravian region**	2 **North-Moravian region**	3 underground gas reservoir Háje

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	96	96	97	97	98
exploited	64	63	64	67	66
Total mineral *reserves, mill m^3	30,546	30,594	30,339	30,203	30,071
economic explored reserves	7,236	7,116	6,994	6,799	6,757
economic prospected reserves	2,951	2,852	2,807	2,725	2,776
potentially economic reserves	20,479	20,626	20,538	20,679	20,538
exploitable (recoverable) reserves	4,801	4,623	9,829	10,105	4,098
Mine production, mill m^3	171	179	146	138	153

** See NOTE in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	mill m^3	16 767	16 767	16 767	16 767	16 767
P_2		–	–	–	–	–
P_3		–	–	–	–	–

5. Foreign trade

271121 – Natural gas

		2017	2018	2019	2020	2021
Import	ths m^3	6,662,572	5,926,963	7,481,881	6,210,123	6,383,792
Export	ths m^3	472,544	415,513	645,242	782,138	1,008,928

271121 – Natural gas

		2017	2018	2019	2020	2021
Average import prices	CZK/ths m^3	6,996	8,281	5,906	3,962	11,941
Average export prices	CZK/ths m^3	6,943	9,185	6,132	4,381	4,370

Natural gas import to the Czech Republic

	2017			2018			2019			2020			2021		
Země	ths m^3	ths CZK	CZK/ ths m^3	ths m^3	ths CZK	CZK/ ths m^3	ths m^3	ths CZK	CZK/ ths m^3	ths m^3	ths CZK	CZK/ ths m^3	ths m^3	ths CZK	CZK/ ths m^3
Austria	6	187	N	6	235	N	5	172	N	1	433	N	<1	707	N
Germany	218,993	1,537,205	7,019	265,397	2,313,219	8,716	746,572	4,519,729	6,054	1,696,475	5,982,503	3,526	–	–	–
Denmark	32,507	237,228	7,298	2,586	7,334	2,836	3,694	6,322	1,711	–	–	–	1	2,788	N
France	190	1,172	6,166	3,887	26,548	6,831	295	1,998	6,782	–	–	–	–	–	–
Switzerland	1,151	17,179	14,930	535	1,710	3,198	1,808	3,937	2,178				–	–	–
Luxemburg	451	3,735	8,274	–	–	–	–	–	–	–	–	–	–	–	–
Norway	W	W	–	–	–	–	W	W	–	–	–	–	–	–	–
Poland	<1	3	N	–	–	–	–	–	–	–	–	–	–	–	–
Countries and territories not mentioned	786,329	5,636,653	7,168	85,178	632,071	7,421	–	–	–	–	–	–	3	7,823	3,313
Countries and territories not covered by intra – EU trade	2	6	2,970	–	–	–	–	–	–	–	3,746	4,631	–	–	–
Russia	5,630,935	39,166,064	6,968	5,565,633	46,295,240	8,318	6,174,659	37,127,850	6,013	4,512,596	18,616,058	4,125	521	6,343	11,949
Slovakia	1,992	13,832	6,944	4,248	39,143	9,214	14,835	57,856	3,900	< 1	21	N	< 1	N	N
USA	<1	4	N	–	–	–	< 1	117	N	–	–	–	–	–	–
Italy	–	–	–	–	–	–	250	1,729	6,904	242	1,649	6,813	–	–	–

Note: W – witheld to avoid private companies confidential data
Source: CZSO

6. Prices of domestic market

Prices of domestic producers are open to public incompletely.

Unigeo a.s. shows data in its Annual Reports for 2017–2021 which allow to deduct approximate average prices of natural gas supply to local gas distribution system (GasNet s.r.o.):

	2017	2018	2019	2020	2021
Unigeo a.s. price – CZK/m^3	< 4,8	< 4,7	6	3	11

Trading on the Energy Exchange of the Czech Moravian Commodity Exchange Kladno (CMKBK) with the SSDP (composite natural gas supply services of gas products (commodity)) – price quotation*) averages weighted by realized quantity

		2017	2018	2019	2020	2021
To 630 MWh/delivery point (630 MWh = 59,684 m^3)	CZK/MWh **)	455	616	533	406	1,277
	CZK /ths m^3 ***)	4,803	6,499	5,629	4,291	13,486
Over 630 MWh/delivery point (630 MWh = 59,684 m^3)	CZK /MWh **)	460	613	526	382	988
	CZK /ths m^3 ***)	4,858	6,470	5,557	4,037	10,427

Source: Czech Moravian Commodity Exchange Kladno
Explanations:
*SSDP (**sdružené služby dodávky zemního plynu**) = composite natural gas supply services of gas products (commodity) = natural gas physically delivered into the customers offtake point on the territory of the Czech Republic with obligation of the customer to take delivery of the gas from the distribution network (gas grid) and responsibility of the holder of the natural gas trading licence (supplier) for any deviations in line with relevant legal regulations according to the Energy Act and the relevant implementing and related regulations in force including distribution of natural gas and the system services.*
**) Prices are quoted in CZK without VAT, gas tax or any other indirect tax or similar payment and do not include distribution of natural gas and related services*
***) Original format of quoted prices*
****) Recalculated quoted prices with using of calorific value 1 MWh = 94.74 m^3 of natural gas*

7. Mining companies in the Czech Republic as of December 31, 2021

MND a.s., Hodonín
Green Gas DPB, a.s., Paskov
LAMA GAS & OIL s.r.o., Hodonín
Unigeo a.s., Ostrava – Hrabová
UNIMASTER spol. s r.o., Praha

8. World production and world market prices

World mine production

The volumes of world natural gas production in recent years were as follows

	2017	2018	2019	2020	2021
World natural gas production (WBD), mill m^3	3,024	3,164	3,261	3,174	N
World natural gas production (BP), mill m^3	3,674	3,852	3,968	3,862	4,037

Note: BP – BP Statistical Review of World Energy 2022.

Main producers according to BP

2021		
Country	**mill m³**	**%**
USA	934	23.1
Russia	702	17.4
Iran	257	6.4
China	209	5.2
Qatar	177	4.4
Canada	172	4.3
Australia	147	3.6
Saudi Arabia	113	2.9
Norway	112	2.9
Algeria	82	2.5
World	**4,037**	**100.0**

Natural gas prices in various countries according to the BP Statistical Review of World Energy 2022 (USD/mill Btu converted to USD/m³ and USD/MWh)

Country/year		2017	2018	2019	2020	2021
Germany, average import price	USD/mill Btu	5.62	6.66	5.03	4.06	8.94
	USD/MWh	19.18	22.71	17.16	13.84	30.51
	USD/m³	0.20	0.24	0.19	0.15	0.33
United Kingdom, Heren NBP Index	USD/mill Btu	5.80	8.06	4.47	3.42	15.80
	USD/MWh	19.79	27.51	15.24	11.66	53.92
	USD/m³	0.25	0.29	0.17	0.12	0.59
USA, Henry Hub, spot price	USD/mill Btu	2.96	3.12	2.51	1.99	3.84
	USD/MWh	10.10	10.64	8.56	6.79	13.11
	USD/m³	0.11	0.11	0.09	0.08	0.14
Canada (Alberta)	USD/mill Btu	1.58	1.18	1.27	1.58	2.75
	USD/MWh	5.39	4.02	4.33	5.39	9.39
	USD/m³	0.06	0.04	0.05	0.06	0.10
Holland (TTF)	USD/mil. Btu	5.72	7.90	4.45	3.07	16.02
Japan (CIF), price LNG	USD/mil. Btu	8.10	10.07	9.94	7.78	10.07

Note:
1) The price conversion from USD/mill Btu to USD/m³ was performed by the use of the following ratios:
1 ft³ (cubic foot) of natural gas = 1,050 Btu (British thermal unit); 1 m³ = 35.31 ft³; 1 m³ = 37,075.5 Btu
2) 3,412,969 Btu = 1 MWh

Uranium

1. Characteristics and use

Average U content (and its extent) in the earth's crust (ppm)

2.5 (0,003–4.8) U

Industrially important minerals

Uraninite K(Th,TR,UO_2).mPbO (up to 92% U), nasturane KUO_2.mPbO (up to 90% U), uranium black $UO_{2.70–2.93}$ (up to 60% U), coffinite $U[SiO_4(OH_4)_4]$ (up to 67% U), carnotite $(K_2(UO_2)_2(V_2U_8).3H_2O$ (up to 64% U), autunite $Ca(UO_2)(PO_4)_2.6H_20$

Industrially important deposit types

1. Infiltration in sandstones: basin Chu-Sarysu and Syr Darya (Kazakhstan), Kyzylkum (Uzbekistan), Wyoming (USA), Tim Mersoi (Niger), Königstein (Germany), Hamr, Stráž (Czech Republic)
2. Discordant – „unconformity“: Athabasca District (Canada), Ranger (Australia)
3. Felsic intrusions: Rössing, Husab (Namibia), Dalongshan (China)
4. Magmatic-hydrothermal: Olympic Dam (Australia)
5. Fossil river placers: Witwatersrand (South Africa), Elliot Lake (Canada)
6. Volcanic: Streltsovsk (Russia), Fushou, Benxi (China), Dornod (Mongolia), Kurišková-Jahodná (Slovakia)
7. Metasomatic: Ingulskoye, Smolinskoye (Ukraine), Caetité/Lagoa Real (Brazil)
8. Vein: Beaverlodge (Canada), Jaduguda, Turamdih (India), Chongyi, Lantian (China), Aue-Schlema (Germany), Příbram, Rožná (Czech Republic)

Reserves

2019		
Country	**t**	**% world**
Australia	1,692,700	27.5
Kazakhstan	906,800	14.7
Canada	564,900	9.2
Russia	486,000	7.9
Namibia	448,300	7.3
South Africa	320,900	5.2
Brazil	276,800	4.5
Niger	276,400	4.5
China	248,900	4.0

2019		
Country	**t**	**%**
Mongolia	143,500	2.3
Uzbekistan	132,300	2.2
Ukraine	108,700	1.8
Botswana	87,200	1.4
Tanzania	58,200	0.9
Jordan	52,500	0.9
USA	47,900	0.8
Other	295,800	4.8
World	**6,147,800**	**100.0**

Source: Uranium 2020: Resources, Production and Demand ("Red Book")

2020			
Country	**t**	**% world**	**% EU**
EU	64,645	1.1	100.0
Spain	34,350	0.6	53.1
Slovenia	12,200	0.2	18.9
Sweden	9,595	0.2	14.8
Portugal	7,000	0.1	10.8
Finland	1,500	0.0	2.3
Czech Republic	866	0.0	1.3

Resources calculated at the level of recoverable identified recources (reasonably assured resources plus inferred resources) at uranium prices below USD 130/kg.

In addition to the above classification (condition of resource evaluation) and the inventory of resources of the EU, reserves of 17,956 tonnes of uranium in Hungary are reported in the EU.

Uses

Energy industry, military (nuclear ammunition, anti-tank ammunition from depleted uranium), radioisotopes (medicine, defectoscopy), glassmaking, ceramics

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic was one of the world's most important uranium producers. Historically, with a total production of about 112 thousand t of uranium in the years 1946 to 2019 in the form of sorted ores (from the beginning of mining until 1975) and chemical concentrate (since 1953), the Czech Republic ranks 12th in the world. The peak of uranium ore mining in the Czech Republic took place from the end of the 1940s to the beginning of the 1990s, when it was terminated due to high production losses in all vein deposits mined until then (except Rožná). In 1995, mining at the Hamr deposit ended for the same reason, and a year later, for mainly ecological reasons, at the Stráž deposit, mining at the sandstone-type deposits was terminated. From then until the end of 2016 (in 2017, the mined ore was obtained as part of the processing of residual structures in uranium ores during the clearing of stopes before their abandonment and the implementation of preparatory liquidation work) in the Czech Republic only the Rožná vein deposit. The closure of the Rožná deposit probably ended the uranium mining in the Czech Republic for a long time (if not definitively). During the peak of mining (1955–1990), the annual production of uranium ranged between 2,000 and 2,900 tonnes (max. slightly over 3,000 t in the years 1959 to 1960 and 1962 to 1964). Then, within three years, it dropped to about 600 and remained around this value until 1999. Since 2000, the mined amount has been declining slowly but steadily to 128 t in 2016, when the mining of U ores was terminated. Since then, uranium has been obtained from the remediation of closed mines in the amount of 30–40 t U per year. While in 1990 share in world mining reached more than 4%, between 1994 and 2003 it was around 2%, after 2005 it has already fallen below 1% and currently (2018) our republic with a production of around 35 tonnes per year ranks 14th in the world with less than 0.1% share in worldwide mined amount.

Usable uranium accumulations were found both in the crystalline complex bedrock and in the overlying formations of the Bohemian Massif. There are two main stages in the formation of uranium ores – late Variscan and Alpine.

Depending on the geological environment, according to the IAEA classification, there were practically only two types of deposits in the Czech Republic – vein and sandstone. From the point of view of metal production, hydrothermal vein deposits (veins in metamorphites, zone deposits in metamorphites and along large faults in granitoids) were of the greatest importance. The total production of U metal from these types of deposits was almost 84 kt. The second place in terms of production (a total of 29.5 kt U) is occupied by deposits of uranium–bearing sandstones of the Czech Cretaceous basin. The remaining less than 0.9 kt U is then accounted for by deposits in permocarbon and tertiary sediments (according to the IAEA classification, mainly of the coal or lignite type). The vast majority of the uranium mined – almost 86% – was mined by traditional underground mining. About 400 t of uranium were mined by surface quarries, which represents about 0.3% of the total amount. The remaining part of uranium (about 14%) was obtained mainly by underground leaching from wells (in situ leaching).

Vein deposits in the Czech Republic were divided into 3 subtypes:

- Veins and venous systems of hydrothermal origin in metamorphic rocks. The ore mineralisation with the predominant uraninite is very uneven, contrasting and it is spatially and genetically related to the massifs of the Variscan granitoids. Mostly steeply inclined ore bodies (veins) have a thickness of a few cm to 1 m, rarely more. The U contents in these deposits mostly ranged from 0.1 to several tenths of a percent, exceptionally up to about 1%. This type included the largest Czech and one of the world's largest hydrothermal vein deposits Příbram, formerly important deposits Jáchymov, Horní Slavkov, and some smaller deposits, such as Licoměřice-Březinka, Zálesí u Javorníka, Předbořice, Chotěboř, Slavkovice, Lázně Kynžvart-Kladská, Planá u Mariánských Lázní-Svatá Anna, etc.
- Blurred graphitised and chloritized or only chloritized ore-bearing crushed zones in metamorphic rocks, mostly with steep dip. The ore mineralisation is uneven, mostly disseminated with the main minerals uraninite, coffinite and brannerite. The ore bodies have a plate-like shape with thicknesses of several meters to 10 m and the U contents in the deposits ranged from around 0.09 to 0.3%. This includes, for example, the last mined Rožná deposit, Zadní Chodov, Olší, Okrouhlá Radouň, Dyleň, Jasenice-Pucov, etc.
- Ore mineralisation bound to chloritized tectonic zones in Variscan granitoids mainly with uraninite-coffinite-brannerite mineralisation. The ore mineralisation is relatively uniform and forms columnar or lenticular bodies, mostly steeply inclined. The U contents in the deposits mostly ranged between 0.07 and 0.13%. The most important deposit of this type was Vítkov 2, other examples are Nahošín and Lhota u Tachova.

Deposits in uranium-bearing sandstones

- Predominantly stratiform ore mineralisation in waterbearing Cenomanian silty sandstones of the Lusatian development of the Czech Cretaceous basin, formed mainly by uraninite and U-blacks, in some places also by hydrozirconium. The ore bodies are placed horizontally or sub-horizontally and have a layered, plate-shaped and less lenticular shape with thicknesses between a few decimetres and a few metres. The ore mineralisation is part of the matrix and is relatively evenly distributed. The U grades in deposits range on average from 0.03 to

0.14%. The deposits in the vicinity of Stráž pod Ralskem were of decisive importance, where both traditional deep mining (Hamr, Břevniště, Křižany) and leaching of ore from boreholes (Stráž) took place. Other proven deposits (Osečná-Kotel) and prognostic resources (Hvězdov, Mimoň, Heřmánky, etc.) have not yet been mined. More than 98% of registered reserves in the Czech Republic (mostly potentially economic = irrecoverable resources) are tied to this type of deposits. Uranium reserves would be economically recoverable mainly by in situ leaching (ISL) (= in situ recovery (ISR)), which is currently not ecologically acceptable.

Other deposits

- Stratiform mineralisation in the sediments of the Late Paleozoic, formed by uranium-bearing coal seams and surrounding rocks in the Pennsylvanian (= Upper Carboniferous) and Lower Permian in the Intra Sudetic Basin (e.g. Radvanice, Rybníček, Svatoňovice) and in the Kladno-Rakovník Basin (Jedomělice, Rynholec). The ore mineralisation, consisting mainly of uraninite, had the shape of small slightly inclined irregular lenses, or plates at most several decimetres thick. The average U content in the deposits ranged from 0.1 to 0.3%.
- Stratiform ore mineralisation in the eastern part of the Sokolov Basin (e.g. Mezirolí, Podlesí) and its Hroznětín part (e.g. Hájek, Ruprechtov, Hroznětín). Irregular ore mineralisation in sediments enriched with organic material (including coal), consisting mainly of uranium blacks, was mostly in the form of smaller plates and lenses with thicknesses from decimetres to at most several metres. U grades averaged between 0.1 and 0.2%.

Economically important and especially intensively used deposits in the past were concentrated in five areas. In the following overview, the areas with the type of ore and the most important deposits are listed according to the importance given by the amount of uranium mined. The percentage share of the area in the total extraction is added in brackets.

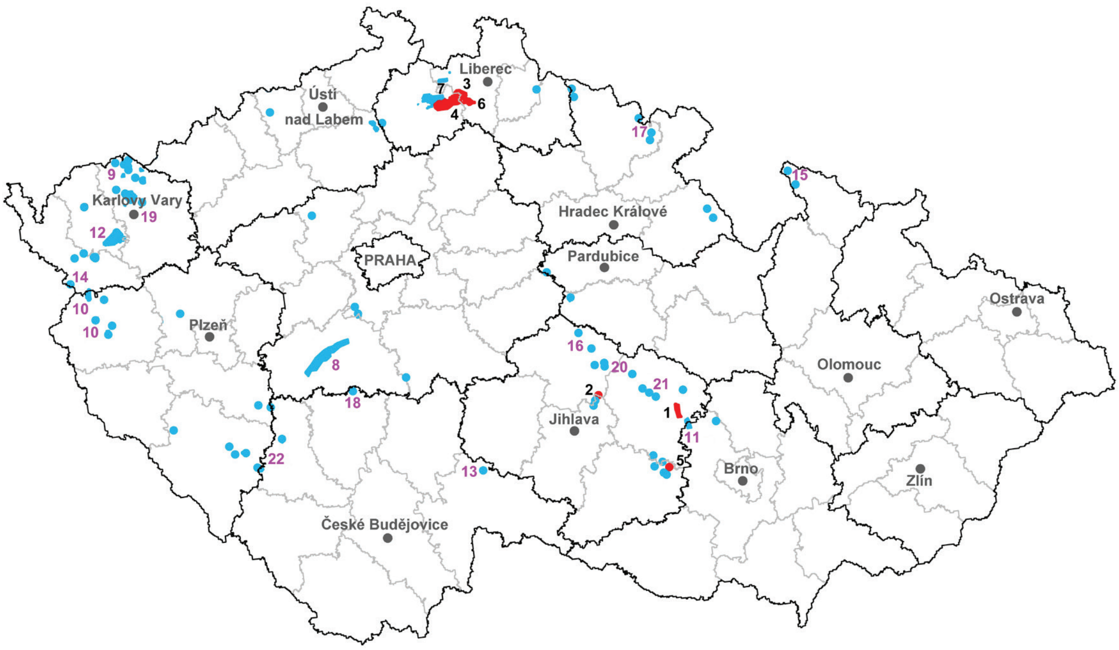
- Central Bohemian – vein ore mineralisation: e.g. Příbram, Předbořice (almost 40% of total metal mined)
- North Bohemian – ore mineralisation in Cretaceous sediments: e.g. Stráž pod Ralskem, Hamr pod Ralskem, Břevniště pod Ralskem (around 24%)
- Moravian – zone and vein ore mineralisation: Rožná, Olší (about 21%)
- West Bohemian – zone and vein ore mineralisation: e.g. Zadní Chodov, Vítkov 2, Horní Slavkov, Dyleň (less than 10%)
- Krušné hory – vein deposits and ore mineralisation in Tertiary sediments: e.g. Jáchymov, Hájek (less than 7%)

Other small deposits and occurrences scattered over the remaining territory of the Bohemian Massif, e.g. in Železné Hory, Rychlebské Hory, Krkonoše and at the Okrouhlá Radouň deposit, contributed the remaining 2% to the total amount of approx. 112 thousand tonnes U mined after World War II.

All extracted raw material was chemically treated and the final product was a chemical uranium concentrate sold abroad (in 2015 to Canada. France and Russia). In the last 25 years. The energy company ČEZ a.s. (ČEZ) has been the almost exclusive customer of uranium concentrate. Uranium consumption purchased fuel elements at the Dukovany and Temelín nuclear power plants has ranged from 650 to 700 tonnes per year in recent years.

The setting pit in Stráž pod Ralskem where leachate waste from the deposit containing 0.030 to 0.063% of rare earths (lanthanum to gadolinium) has accumulated for 30 years, but also scandium, yttria, niobium, zirconium and hafnium is a potential resource of these metals. Apart from Zr the reserves of these metals have not yet been evaluated.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits

exhausted deposits and other resources

Reserved registered deposits

1 Rožná
2 Brzkov
3 Břevniště pod Ralskem
4 Hamr pod Ralskem
5 Jasenice-Pucov
6 Osečná-Kotel
7 Stráž pod Ralskem*

* *uranium is recovered only as a byproduct from the treatment of groundwater and technological solutions during mine liquidation and reclamation work upon termination of in-situ leaching (ISL), otherwise in situ recovery (ISR), of uranium ores*

Exhausted deposits and other resources

8 Příbram
9 Jáchymov
10 Zadní Chodov + Vítkov 2
11 Olší
12 Horní Slavkov
13 Okrouhlá Radouň
14 Dyleň
15 Javorník
16 Licoměřice-Březinka
17 Radvanice + Rybníček + Svatoňovice
18 Předbořice
19 Hájek + Ruprechtov
20 Chotěboř
21 Slavkovice
22 Mečichov-Nahošín

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	7	7	7	7	7
exploited	1	1	0	0	0
Total mineral * reserves, t U	134,948	134,948	134,862	134,833	134,825
economic explored reserves	1,300	1,300	1,300	1,300	1,300
economic prospected reserves	19,448	19,448	19,448	19,448	19,448
potentially economic reserves	114,200	114,166	114,114	114,085	114,077
exploitable (recoverable) reserves	276	276	276	276	276
Mine production, t U	56	34	33	29	27
Production of concentrate, t U **	59	29	33	28	26

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

*** sales production (without ore milling losses)*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	t U	214,253	214,253	214,253	233,769	233,769
P_2,	t U	12,319	12,319	12,319	17,736	17,736
P_3		–	–	–	–	–

Other* prognostic resources P_1, P_2, P_3

Year	2017	2018	2019	2020	2021
P_1	–	–	–	–	–
P_2	–	–	–	–	–
P_3	–	–	–	–	–

** Prognostic resources of uranium-bearing sandstones type in the Bohemian Cretaceous Basin, unexploitable at the present time*

5. Foreign trade

28441030 – Natural uranium – wrought

		2017	2018	2019	2020	2021
Import	t U	<1	0	0	0	0
Export	t U	170,588	0	0	0	0

28441030 – Natural uranium – wrought

		2017	2018	2019	2020	2021
Average import prices	CZK/kg U	> 207,000	–	–	–	–
Average export prices	CZK/kg U	2 155	–	–	–	–

6. Prices of domestic market

Mined uranium is exported.

7. Mining companies in the Czech Republic as of December 31, 2021

DIAMO, s.p., Stráž pod Ralskem

8. World production and world market prices

World mine production

In recent years the volume of world production of uranium in a concentrate expressed in terms of the U_3O_8 and U content of concentrates was as follows:

	2017	2018	2019	2020	2021
Uranium production, U_3O_8 (according to WBD)	70,402	64,083	64,418	56,269	N
Uranium production, t U (according to WNA*)	60,514	54,154	54,742	47,731	48,332

Note:

*1) * Uranium mining production. World Nuclear Association. September 2022.*

2) 1 t U = 1.179 t U_3O_8

According to the Uranium Investing News.com (INN), primary U production has been in recent years identical to World Nuclear Association (WNA) data:

Year	2017	2018	2019	2020	2021
Tonnes U	60,514	54,154	54,742	47,731	48,332

Main producers according to WNA

2021		
t U		
Country	**t**	**%**
Kazakhstan	21,819	45.1
Namibia	5,753	11.9
Australia	4,192	8.7
Canada	4,693	9.7
Uzbekistan[e]	3,500	7.2
Russia	2,635	5.5
Niger	2,248	4.7
China[e]	1,885	3.9
India[e]	615	1.3
Ukrain[e]	455	0.9
South Africa[e]	385	0.8
World	**48,332**	**100.0**

e – estimate

According to the WNA in 2021 about 53% of world production was obtained from the following 10 largest deposits which are located in 4 countries:

Deposit	Country	Mining company	Mine type	tonnes U
Cigar Lake	Canada	Cameco / Orano	underground	4,693
Inkai (sites 1-3)	Kazakhstan	Kazatomprom / Cameco	ISL	3,449
Husab	Namibia	Swakop Uranium	Surface	3,309
Krakatau (Budenskoe 2)	Kazakhstan	Uranium One / Kazatomprom	ISL	2,561
Rössing	Namibia	Rio Tinto	surface	2,444
Four Mile	Australia	Quasar	ISL	2,241
Somair	Niger	Orano	surface	1,996
Olympic Dam	Australia	BHP Billiton	underground	1,922
Central Mynkuduk	Kazakhstan	Ortalyk	ISL	1,579
South Inkai	Kazakhstan	Uranium One / Kazatomprom	ISL	1,579
Kharasan 1	Kazakhstan	Kazatomprom / Uranium One	ISL	1,455
TOP 10 total				**25,773**

ISL = in situ leaching (more than half of uranium is extracted worldwide with this technology, in 2021 66%)

ESA average annual prices of natural uranium
(EUR/kg U) according to EU Nuclear Observatory

	2017	2018	2019	2020	2021
Long-term price	80.55	73.74	80.55	71.37	89.00
Spot price	55.16	44.34	58.00	N*	N*

Note: ESA - Euratom Supply Agency. the European Agency for the common supply policy based on the principle of fair and equitable supplies of nuclear fuels to European users
** – In 2020 and 2021 there were not enough trades (less than 3) to represent the average price of European trades*

INDUSTRIAL MINERALS

Industrial minerals are mineral raw materials that are used in industry both treated and untreated; non-metals or their compounds are also obtained from them. After construction and energy minerals, they repre-sent another main group of minerals in the Czech Republic. Ceramic and glass raw materials are traditionally important both in terms of geological reserves and mining. The most important are kaolins from the Pilsen and Karlovy Vary areas, but also from the areas around Kadaň and Podbořany. Furthermore, glass sands from Střeleč and the surroundings of Provodín, feldspars from Halámky, Krásno and Luženičky, clays from the Cheb Basin and Central Bohemia and bentonites from areas around Most, Kadaň and in the last 15 years also Karlovy Vary. Deposits of limestone and cement raw materials also hold considerable geological reserves, and their mining also reaches high volumes.

Kaolin, quartz sands, feldspar, clays, bentonites and limestones are also important export commodities in the minerals sector.

On the contrary, the once important era of mining of graphite, pyrite, fluorite, barite, but also some other industrial minerals has probably definitely ended.

Bentonite

1. Characteristics and use

Bentonite is a soft, very fine-grained, inhomogeneous, differently coloured rock composed essentially of the clay mineral montmorillonite ($xM^+(Al_{2-x}Mg_x)Si_4O_{10}(OH)_2$), which was formed mostly by subaquatic or subaerial weathering of volcanic products (especially glassy felsic ashes). Montmorillonite is a carrier of characteristic properties of bentonite – considerable sorption capacity characterised by high value of base exchange (ability to accept certain cations from solutions and release Mg from its molecule instead them, sometimes Ca and alkalis), internal swelling in contact with water (some bentonites do not swell, but they have high absorbency like bleaching clays (especially when activated), high plasticity and cohesion. Bentonite also contains other clay minerals (kaolinite, illite, beidellite), Fe compounds, quartz, feldspar, volcanic glass, etc., which are pollutants and are removed by treatment if possible.

Reserves

They are extensive worldwide.

Uses

It is versatile and depends on its mineralogical composition and technological properties. It is mostly used as a binder in foundry, in the pelletisation of iron ores (4–10 kg per a tonne of pellets), it is also used as a sorbent (decolourisation, catalysts, refining, filtration, desiccants, wastewater treatment, pesticide carriers), in drilling fluids, as fillers (paints, varnishes, pharmaceuticals, cosmetics) and suspensions (lubricating oils), in construction (sealing material), agriculture, etc. Recently, the consumption of bentonite as a sorbent of domestic animal excrements (cat litter) and as a binder in granulated feed has increased significantly.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

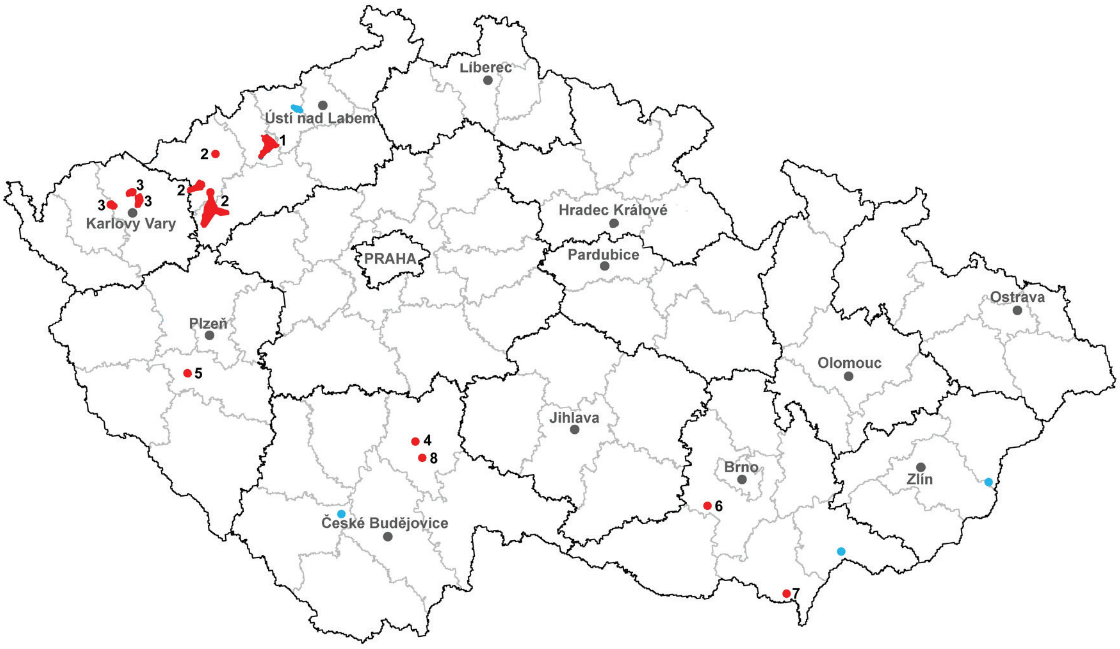
2. Mineral resources of the Czech Republic

All bentonite deposits in the Czech Republic were formed by argillization of volcanic rocks. The vast majority of bentonite deposits and reserves in the Czech Republic are concentrated in the area of the Doupov Mountains and the Central Bohemian Uplands. A significant part of the raw material from bentonite deposits in these areas consists of the highest quality raw material suitable primarily for foundry purposes (binder of foundry sands in moulding) – both activated (replacement of Ca^{2+} a Mg^{2+} ions by Na^+ ions) and non-activated bentonite. The development of mining, processing and use of bentonites in the Czech Republic occurred at end of the 1950s, especially in connection with its use in foundry. Mining culminated first in the early and late 1980s (207 kt in 1987); there was a decline in mining in the first half of the 1990s in connection with the decline in demand from the foundry industry (54 kt in 1995). In 1996–2000, mining increased significantly once again, mainly due to increased demand for differently applied raw materials (litter, feed, sealing materials, etc.), then it stabilised for several years and culminated in 2007 after another increase.

- The most important deposit area is the eastern edge of the Doupov Mountains at the junction with the North Bohemian Basin. Most of the reserves and the largest bentonite deposits in the Czech Republic are concentrated in the vicinity of Kadaň and Podbořany. The most important currently mined deposit in this area is the Rokle u Kadaně. Bentonites from the Nepomyšl deposit near Podbořany are occasionally used, but still to only a small extent.
- In the area of the western edge of the Doupov Mountains, in contact with the Hroznětín Basin, bentonite deposits are concentrated mainly in the vicinity of Hroznětín. Due to economic reasons, mining and processing activities were terminated in 1993 at the Hroznětín-Velký Rybník deposit. Relatively large reserves in several deposits were verified in the late 1990s. However, most of these deposits (except for the Všeborovice deposit) have unfavourable overburden conditions, are less explored and sometimes have a worse quality composition of the raw material than deposits in the Podbořany, Kadaň and Most regions. Bentonites in the Sokolov Basin are of growing importance, where a suitable raw material (montmorillonite clay) from kaolin overburden has been processed for litter production since 2004, first mainly from the Božičany-Osmosa-jih deposit and gradually also from some other deposits in the area (Mírová, Podlesí, Ruprechtov, Otovice).
- Deposits in the Most region at the junction of the south-eastern edge of the North Bohemian Basin and the Central Bohemian Uplands were in the past the most important bentonite areas in the Czech Republic. The most important deposits in the area include Braňany-Černý vrch deposit that is currently at the end of its capacity and its northern surroundings (Braňany 1); the Stránce and Střimice deposits, for example, are already abandoned today.
- Until recently, the Tertiary basins of the Plzeň region (Dnešice) and the South Bohemian Basin (Maršov, Rybova Lhota) were of minor importance. The raw material (mostly montmorillonite clays) is usually of poorer quality and can be used mainly in agriculture or as a sealing material, but currently mainly for the production of litters – this is the case of the Maršov deposit, the production of which has increased significantly in recent years.
- In 2014, overlying suitable montmorillonite clays, mined as part of opening works at the Plesná-Velký Luh kaolin deposit in the Cheb Basin, also began to be used for the production of litters.
- Montmorillonite clays predominate in the Miocene sediments of the Carpathian Neogene in southern Moravia. With a few exceptions (Ivančice-Réna), this is a lower quality raw material, suitable primarily for agriculture or as a sealing material. Two small, now unused deposits (Ivančice-Réna, Poštorná) are evaluated here.

Since 2006, bentonite has been kept in the Register as one raw material type – foundry bentonite and its other types have been merged.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

Principal areas of deposits and deposits outside them

*(Names of areas and the mined deposit outside are indicated in **bold type**)*

1 **České středohoří Mts.**

2 **Doupovské hory Mts.**

3 **Sokolov Basin**

4 **Maršov u Tábora**

5 Dněšice – Plzeňsko jih

6 Ivančice – Réna

7 Poštorná

8 Rybova Lhota

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	38	38	39	38	39
exploited	9	10	10	9	9
Total mineral *reserves, kt	310,367	310,355	309,801	309,599	323,772
economic explored reserves	78,103	78,103	77,571	77,369	82,614
economic prospected reserves	126,877	126,880	126,877	126,877	134,488
potentially economic reserves	105,387	105,372	105,353	105,353	106,670
exploitable (recoverable) reserves	30,396	32,276	31,994	32,182	32,182
Mine production, kt**	254	277	357	226	198

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

*** Including montmorillonite clays from kaolin deposits overburden*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	27,017	27,017	27,017	27,017	27,017
P_2,	kt	36,361	36,361	36,361	36,361	36,361
P_3		–	–	–	–	–

5. Foreign trade

250810 – Bentonite

		2017	2018	2019	2020	2021
Import	kt	70	68	75	62	71
Export	kt	170	163	166	170	180

250810 – Bentonite

		2017	2018	2019	2020	2021
Average import prices	CZK/t	1,934	1,985	2,453	3,007	3,125
Average export prices	CZK/t	3,112	3,094	3,251	3,530	3,501

250820 – Decolourizing earths and fuller's earth

		2017	2018	2019	2020	2021
Import	kt	0	0	0	0	0
Export	kt	0	0	0	0	0

250820 – Decolourizing earths and fuller's earth

		2017	2018	2019	2020	2021
Average import prices	CZK/t	–	–	–	–	–
Average export prices	CZK/t	–	–	–	–	–

6. Prices of domestic market

Bentonite prices are not quoted.

7. Mining companies in the Czech Republic as of December 31, 2021

Sedlecký kaolin a.s., Božičany
KERAMOST, a.s., Most
KSB s.r.o.

8. World production and world market prices

World mine production

	2017	2018	2019	2020	2021[e]
World mine production (according to MCS), kt	20,600	21,000	16,300	18,200	18,000
World mine production (according to WBD), kt	21,196	21,778	21,796	20,847	N

e – preliminary values

Main producers according to MCS

2021e		
Country	**kt**	**%**
USA	4,300	23.9
India	3,500	19.4
China	2,500	13.9
Turkey	1,700	9.4
Greece	1,300	7.2
Iran	420	2.3
Germany	350	1.9
Czech Republic	230	1.3
Spain	220	1.2
Brazil (beneficiated)	200	1.1
Ukraine	180	1.0
World	**18,000**	**100.0**

e – preliminary values

Main producers according to WBD

2020		
Country	**kt**	**%**
China	5,600	26.9
USA	4,240	20.3
India	3,600	17.3
Turkey	1,658	8.0
Greece	1,170	5.6
Germany	333	3.5
Iran	715	3.4
Russia	720	1.6
Slovakia	261	1.3
Japan	250	1.2
Czech Republic	226	1.1
World	**20,846**	**100.0**

Prices of traded commodities

Commodity/year		2017	2018	2019	2020	2021
Bentonite, U.S. market price, ex works, average (MCS)	USD/st	99	98	98	98	94
Slovakian bentonite, yearly average price of exports to the Czech Republic (CZSO)	EUR/t	55.56	53.93	49.71	53.64	66.78

Clays

1. Characteristics and use

Clays are sedimentary or residual unconsolidated rocks composed of more than 50% clay in the sense of grain size fraction (grain size below 0.002 mm) and containing as an essential component clay minerals, especially kaolinite groups, as well as hydro-micas (illite) and montmorillonite (see bentonite). According to the composition of clay minerals, clays are divided into monomineral (e.g. kaolinite, illite, etc.) and polymineral (composed of several clay minerals). The clays also contain various impurities, such as quartz, micas, carbonates, organic matter, oxides and hydroxides of Fe and others. The colours vary based on the admixtures – white, grey, yellow, brown, purple and usually green and more. Secondary, they can be consolidated – claystones, or in addition non-metamorphically recrystallized – clay shales.

In terms of deposits and technology, this category includes a wide range of rocks with a high content of clay minerals. In the world, clays often include bentonites and brick raw materials, but also kaolins. Clays occur in virtually all sedimentary formations around the world. Reserves:

Reserves

They are extremely large worldwide.

Uses

They are mostly used in ceramic production, as refractory materials, fillers, sealants, in the paper industry, for oil filtration, etc.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

According to technological properties and usability, clays are divided in the Czech Republic as follows:

- Porous – raw material for ceramic production with white or light baking paint, sintering at temperatures above 1,200 °C. Kaolinite predominates among clay minerals, the contents of clastic particles are low.
- Refractory for grog – the raw material after burning out provides a material suitable as grog for the production of fireclay products. The highest possible content of Al_2O_3, the lowest possible content of Fe_2O_3, high heat resistance and the lowest possible absorbency after burning out are required for the raw material. The main clay mineral is again kaolinite (or dickite).
- Refractory others – raw material usable as a binding (plastic) component in the production of mainly refractory products. In addition to high bond strength, the lowest possible content of Fe_2O_3 and clasts is required.
- Non-refractory ceramic – a raw material with wide technological properties and uses (e.g. stoneware, tiles, additives, etc.).
- Aluminium subsoil – kaolinitic clays in the subsoil of coal seams of the Most part of the

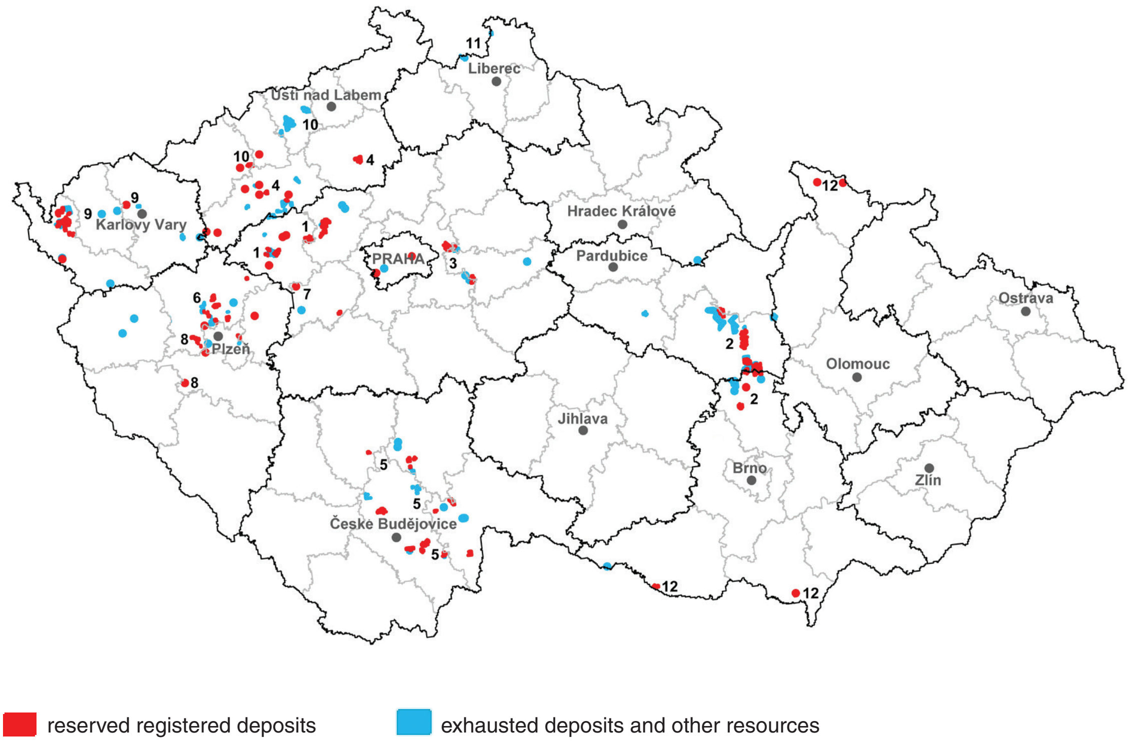
North Bohemian Basin, containing about 40% Al_2O_3, in some places 3–7% TiO_2 and mostly a considerable amount of siderite. In the past, they were considered as a possible source of Al. Today, they are no longer important due to the energy intensity of production and, in addition, they are mostly covered with coal mine dumps.

Deposits and clay resources in the Czech Republic are concentrated in the following main deposit areas:

- Kladno-Rakovník Permocarbon – mainly highly refractory claystones (schistous clays), which are used for the production of refractory grogs. Red-burning tile clays and grey non-refractory claystones are also less represented. The most important deposit of highly refractory claystones is the mined large deposit Rynholec-Hořkovec 2. Until recently, a smaller deposit Lubná-Marta was mined both in the depths (until 2017) and on the surface (until 2018).
- Moravian and East Bohemian Cretaceous – this is the area with the largest reserves of refractory raw material with the same use as in the previous area (with a slightly worse quality of composition). At present, only one deposit is surface mined – Březinka.
- Louny Cretaceous – clays are suitable for similar uses like the porous and refractory others, but mainly like ceramic. At present, only the medium-sized Líšťany deposit of non-refractory clays is used.
- Cretaceous around Prague – clays are suitable as highly refractory clays for grog, refractory binding and as porous. The most important are the used deposits of refractory clays for grog at Vyšehořovice and Brník.
- South Bohemian basins – clays are highly to moderately refractory, especially suitable as binding (other refractory), as well as porous and non-refractory. The main deposits of binding clays are Borovany-Ledenice (where diatomite is also mined), mining also takes place to a lesser extent at the Zahájí-Blana and Jehnědno deposits.
- Pilsen Basin and Tertiary relics of Central and Western Bohemia – moderately refractory clays predominate, which are evaluated as binding and ceramic for the production of tiles, as well as stoneware. The most important is the long-mined large deposit Kyšice-Ejpovice. Smaller mining also takes place at the Vižina deposit of binding clays.
- Cheb and Sokolov Basin – the Cheb Basin is much more important, where there are significant binding clays, porous and refractory ones, stoneware, etc. The critical mined deposit of binding clays not only in the area, but the whole Czech Republic today is Nová Ves u Křižovatky 2. Smaller mining also takes place at other deposits Vackov (binding clays) and Nová Ves and Suchá (porous and binding clays).
- North Bohemian and Zittau basins – in addition to the above-mentioned aluminium base clays, there are also overlying ceramic (stoneware) clays. At present, only the medium-sized deposit of ceramic clays Tvršice in the North Bohemian Basin is mined to a small extent.
- Tertiary and Quaternary in Moravia – there are ceramic (especially stoneware and tile) clays. Smaller mining was renewed here for a short time in 2008–2016 (Poštorná).

The most important areas today are the Cheb and South Bohemian basins, the Cretaceous in the vicinity of Prague, the Rakovník Permocarbon and less and less the Moravian and East Bohemian Cretaceous. Clays and claystones are now only surface mined in the Czech Republic.

3. Registered deposits and other resources of the Czech Republic



Major deposit areas

(Names of areas with exploited deposits are in ***bold****)*

1 **Kladno-Rakovník Carboniferous**
2 **Moravian and East Bohemian Cretaceous**
3 **Cretaceous around Prague**
4 **Louny Cretaceous**
5 **South Bohemian Basins**
6 **Plzeň Basin**
7 **Tertiary relicts of Central Bohemia**
8 **Tertiary relicts of West Bohemia**
9 **Cheb Basin and Sokolov Basin**
10 **North Bohemian Basin**
11 Zittau Basin
12 Tertiary and Quaternary in Moravia

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	108	108	108	108	108
exploited	19	19	13	13	13
Total mineral *reserves, kt	915,914	915,639	911,289	910,937	910,235
economic explored reserves	164,828	164,596	161,859	160,363	160,165
economic prospected reserves	391,585	391,449	390,864	390,826	390,616
potentially economic reserves	359,501	359,594	358,566	359,748	359,454
exploitable (recoverable) reserves	45,096	39,284	39,997	38,747	33,998
Mine production, kt	537	469	441	454	456

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	331,988	331,988	331,988	331,988	331,988
P_2,	kt	38,196	38,196	38,196	38,196	38,196
P_3		–	–	–	–	–

5. Foreign trade

2508 – Other clays (not including expanded clays of heading 6806), andalusite, kyanite and sillimanite, whether or not calcined; mullite; chamotte or dinas earth

		2017	2018	2019	2020	2021
Import	t	102,122	100,711	103,748	93,676	109,227
Export	t	281,636	291,306	304,803	299,105	322,088

2508 – Other clays (not including expanded clays of heading 6806), andalusite, kyanite and sillimanite, whether or not calcined; mullite; chamotte or dinas earth

		2017	2018	2019	2020	2021
Average import prices	CZK/t	3,141	3,275	3,389	4,382	4,533
Average export prices	CZK/t	2,951	2,860	2,883	3,153	3,047

250830 – Refractory (fire) clay

		2017	2018	2019	2020	2021
Import	t	7,418	7,952	8,111	7,439	8,901
Export	t	17,926	19,107	18,243	6,173	7,464

250830 – Refractory (fire) clay

		2017	2018	2019	2020	2021
Average import prices	CZK/t	3,660	3,552	3,139	3,168	3,002
Average export prices	CZK/t	1,755	1,822	1,714	3,555	3,335

250840 – Other clays

		2017	2018	2019	2020	2021
Import	t	14,796	14,489	11,590	7,439	9,286
Export	t	47,233	52,005	61,052	64,147	76,621

250840 – Other clays

		2017	2018	2019	2020	2021
Average import prices	CZK/t	4,229	3,959	3,476	3,168	4,519
Average export prices	CZK/t	1,060	973	905	932	945

250870 – Chamotte or dinas earth

		2017	2018	2019	2020	2021
Import	t	4,552	2,895	2,138	8,046	9,075
Export	t	46,924	57,124	59,555	58,600	58,239

250870 – Chamotte or dinas earth

		2017	2018	2019	2020	2021
Average import prices	CZK/t	7,907	7,364	7,148	7,527	7,161
Average export prices	CZK/t	4,717	4,169	4, 236	4,443	4,359

6. Prices of domestic market

Various qualities of clay have different market prices. Prices are made public in the limited extent only (some producers do not publish them at all). In 2021 they fluctuated generally between CZK 125–5,500 per tonne.

7. Mining companies in the Czech Republic as of December 31, 2021

Whiteware clays
KERACLAY, a.s., Brník

Refractory clays for grog
České lupkové závody, a.s., Nové Strašecí
KERACLAY, a.s., Brník
P-D Refractories CZ a.s, Velké Opatovice

Other refractory clays (ball clays)
LB MINERALS, s.r.o., Horní Bříza

Non-refractory ceramic clays
LB MINERALS, s.r.o., Horní Bříza

8. World production and world market prices

World mine production

There are no recognised figures of world production and world trade with clays (referred to as other refractory clays in our terminology) because of difficulties in classifying these clays on a uniform basis and the questionability of their direct comparability based on quality and use.

World fuller's earth production (MCS)

MCS statistics contains worldwide values of fuller‘s earth production:

	2017	2018	2019	2020	2021e
World production, kt	3,480	3,220	3,180	3,930	4,000

e – preliminary values

World production of fuller's earth (MCS)

2021^{e}		
Country	**kt**	**%**
USA	2,000	50.0
India	730	18.3
Spain	590	14.8
Senegal	120	3.0
Mexico	110	2.8
Turkey	60	1.5
Greece	30	0.8
World	**4,000**	**100.0**

e – preliminary values

In statistics, the group of clays also includes raw materials consisting of minerals and rocks serving for non-clay refractory material production: kyanite, sillimanite, shales, siliceous sandstone (quartzite) – dinas.

World clay resources are extremely extensive.

World market prices

Clay prices are generally not provided. In the reporting period of 2017 - 2021, Industrial Minerals quoted indicative prices of minerals belonging to the sillimanite group, until 2018 in a wider range:

Commodity/year	2017	2018	2019	2020	2021
Ball clay, USA market (MCS), USD/t	49	55	56	58	64
Common clay, USA market (MCS), USD/t	15	16	17	16	16
Fire clay, USA market (MCS), USD/t	13	12	14	13	13
Fuller's earth, USA market (MCS), USD/t	93	88	88	89	88
Fire clay, chamotte, Polish, average import price into the Czech Republic (CZSO), EUR/t	65.80	59.47	49.61	40.48	37.90

Diatomite

1. Characteristics and use

Diatomite is a sedimentary rock composed mainly of microscopic shells of freshwater or marine diatoms. This rock appears in varying degrees of consolidation – it is either loose (diatomaceous earth, infusorial earth) or consolidated (diatomaceous schist, or even hornstone). The loose rock has the form of a very fine-grained sediment. During diagenesis, the shells are partially dissolved and the sediment is impregnated with loose opal, solidified and it undergoes a schist-forming process. According to the degree of porosity, polishing and absorbent schists are distinguished, sometimes even opal hornstone. The chemical composition is completely dominated by SiO_2, the content of which should be as high as possible. From the technological point of view, the porosity, resistance to acids and temperatures, thermal and electrical conductivity, bulk density of the raw material, humidity, chemical composition, etc. are monitored. Pollutant appear in the form of an admixture of clasts, clayey and organic parts (sponges) and increased contents of Al_2O_3, Fe_2O_3 and CaO. Deposits are formed in water basins with a low $CaCO_3$ content with suspended aluminosilicate substances. The most favourable conditions are in cold waters near volcanic areas.

Reserves

They are extensive worldwide.

Uses

The raw material is used for filtration purposes (purest types), for the production of fillers (rubber, paper, cosmetics), for abrasive purposes, in the production of catalyst carriers and in the construction industry for the production of thermal and sound insulation materials.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

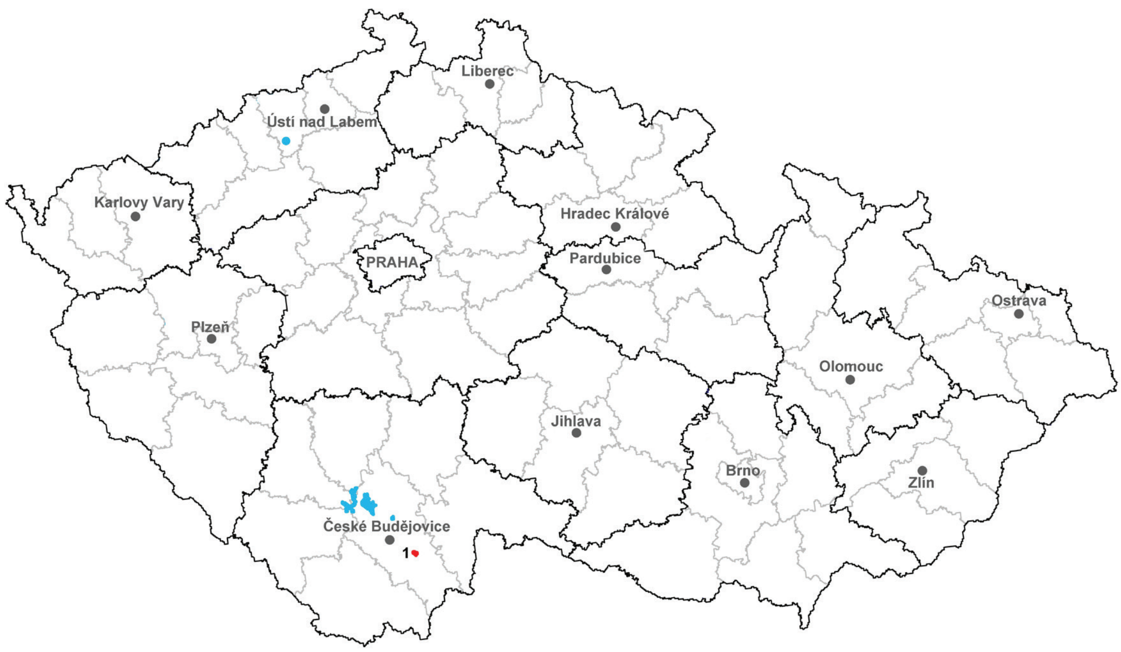
2. Mineral resources of the Czech Republic

Accumulations of diatomite (diatomaceous earth) in the Czech Republic are related to the areas of occurrence of Tertiary and Quaternary lake sediments, especially to Tertiary sediments of the South Bohemian basins, where our only diatomite deposit is located today. Other occurrences are related to occurrence of volcanites in the České středohoří Mts. and there are also smaller occurrences in other places of the Bohemian Massif and in the Neogene of the Carpathian foredeep and flysch.

- The largest accumulations of diatomite in Bohemia are found in the South Bohemian basins. Spongodiatomites and diatomite clays (low-quality building diatomites) occur together with lignites in the Budějovice Basin. The Borovany-Ledenice deposit, located in the Třeboň Basin, is the only registered and at the same time used deposit in the Czech Republic. Tertiary sediments were deposited in a tectonic confined space on the Moldanubian bedrock. The deposit position of diatomites, diatomaceous clays and spongodiatomites is classified as the upper part of the Mydlovary Formation. The diatomites are whitish grey to ochre, unconsolidated and are positioned almost horizontally. The average thickness of the raw material is about 8.5 metres (maximum 15 m). In addition to diatomites, overlying stiffs are also mined at the deposit. Especially pure diatomites are used after treatment for filtration purposes or as fillers in the food, chemical, pharmaceutical and other industries. Diatomites of the highest quality are used in the filtration of wines, liqueurs, beer, edible oils or fats. The others are mostly suitable only for the production of building and insulating materials, or a litter for pets. Other sources and occurrences (e.g. Malovice, Dobřejovice, Zliv, Záboří) in the Budějovice Basin contain diatomite of lower quality with transitions to clays.

- Many outcrops of diatomite are known in the České středohoří Mts., which were occasionally mined in the first half of the 19th century as a raw material for the production of abrasives and polishing materials. The most important former Kučlín deposit was exhausted in 1966. At present, they are no longer important in terms of deposits.
- Lenticular occurrences of diatomites were examined in the Carpathian flysch south of Brno (Pouzdřany), but they were negative in terms of deposits.
- Quaternary diatomites are known from the vicinity of Most (together with organogenic lake mud) and Františkovy Lázně (former Hájek deposit – formerly mined together with peat, now it is the Soos nature reserve), today they are no longer significant as deposits.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

Exploited deposit:

1 **Borovany-Ledenice**

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	1	1	1	1	1
exploited	1	1	1	1	1
Total mineral *reserves, kt	2,397	2,363	2,316	2,266	2,246
economic explored reserves	1,693	1,661	1,616	1,568	1,550
economic prospected reserves	0	0	0	0	0
potentially economic reserves	704	702	700	698	696
exploitable (recoverable) reserves	1,515	2,363	1,441	1,395	1,377
Mine production, kt	34	31	43	46	18

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

5. Foreign trade

2512 – Siliceous fossil meal*, siliceous earth

		2017	2018	2019	2020	2021
Import	t	11,146	12,274	14,148	12,711	9,700
Export	t	16,675	13,063	9,403	4,847	3,941

2512 – Siliceous fossil meal*, siliceous earth

		2017	2018	2019	2020	2021
Average import prices	CZK/t	5,663	5,521	5,371	5,605	7,014
Average export prices	CZK/t	3,846	4,350	4,681	6,930	7,644

*Note: * diatomite*

6901 – Bricks, blocks, tiles and other ceramic goods of siliceous fossil meals

		2017	2018	2019	2020	2021
Import	t	23,423	40,244	29,534	43,053	56,958
Export	t	90	100	589	742	856

6901 – Bricks, blocks, tiles and other ceramic goods of siliceous fossil meals

		2017	2018	2019	2020	2021
Average import prices	CZK/t	1,236	1,215	1,406	1,279	1,405
Average export prices	CZK/t	23,643	23,681	2,415	2,357	2,274

6. Prices of domestic market

Diatomite was sold domestically in 2021 for CZK 12,000–20,500 per tonne.

7. Mining companies in the Czech Republic as of December 31, 2021

LB MINERALS, s.r.o., Horní Bříza

8. World production and world market prices

World mine production

World production of diatomite in the past five years was as follows:

	2017	2018	2019	2020	2021e
World mine production (according to MCS), kt	2,460	2,840	2,190	2,320	2,300
World mine production (according to WBD), kt	2,242	2,310	2,299	2,260	N
World mine production (according to World Mineral Statistics), kt	2,400	2,600	2,100	2,100	N

e – preliminary values

Main producers according to MCS

2021^{e}		
Country	**kt**	**%**
USA	830	36,1
Denmark	400	17,4
Turkey	200	8,7
China	140	6,1
Mexico	100	4,3
Peru	90	3,9
Argentina	90	3,9
France	75	3,3
Germany	50	2,2
Russia	50	2,2
Spain	50	2,2
World	**2,300**	**100,0**

e – preliminary values

Prices of traded commodities (USD/t) according to IM

Commodity/yeark	2017	2018	2019	2020	2021
US diatomite, prices average, FOB works, according to MCS	360	330	340	330	330

Dolomite

1. Characteristics and use

Carbonate rocks with $MgCO_3$ contents above 27.5% and $MgCO_3$ + $CaCO_3$ above 80% are classified as dolomites in the Czech Republic.

Dolomites can be formed directly by precipitation from seawater, but more often they are the result of alteration of limestones by Mg – metasomatosis (dolomitisation) during their diagenesis or by Mg-brines after it. The transformation is often incomplete and subsequent recalcification also occurs, so that sufficiently Mg-rich and homogeneous large bodies of dolomite occur less often compared to Mg-limestone.

Reserves

They are extensive worldwide.

Uses

Pure dolomite is an important raw material for the glass, ceramic and chemical industries. Dolomite rocks are also used for the production of dolomitic limes and hydrates, magnesium cements, refractories in metallurgy, for the desulphurisation of thermal power plant flue gases, for decorative purposes, for the production of fertilizers and fillers, as correctives for acid soils and as industrial fillers. They are also often used for the production of crushed aggregates and for other construction purposes.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Raw material resources of the Czech Republic

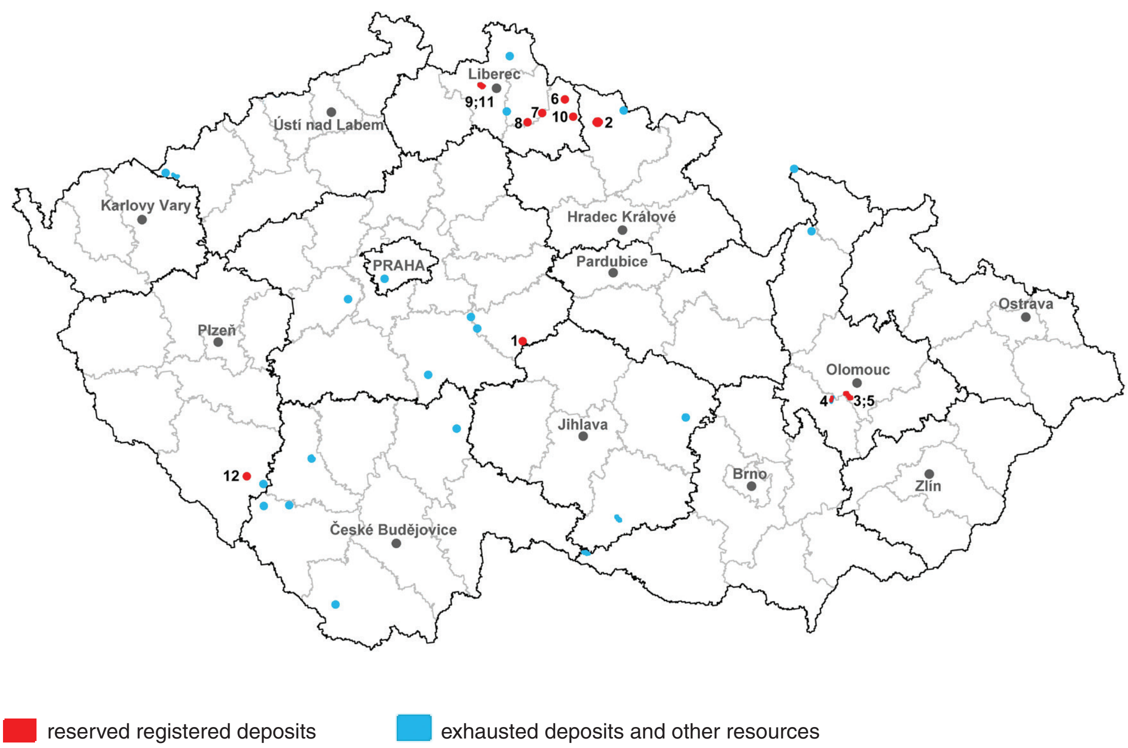
Deposits, resources and occurrences of dolomites and calcareous dolomites in the Czech Republic are concentrated in the following main areas:

- Krkonoše-Jizera crystalline complex with deposits of crystalline calcareous dolomites to dolomites, forming lenses in the surrounding rocks. This area is the most important in the Czech Republic in terms of the number of deposits and the volume of reserves. In Lánov, the largest and most important deposit of dolomites in the Czech Republic, raw material is mined with average contents of MgO almost 19% and CaO around 32%.
- Šumava Mts. and Bohemian Moldanubian with several smaller deposits of pure dolomites (mined Bohdaneč deposit, abandoned Jaroškov deposit) and calcareous dolomites (e.g. Podmokly, Krty).
- The Ore Mountains crystalline complex with several small deposits in the vicinity of Kovářská and Přísečnice (e.g. the exhausted deposit of pure dolomite Vykmanov).
- The Moravian branch of the Moldanubicum with small occurrences of often high-quality dolomite (the exhausted Dolní Rožínka deposit) and little-explored projected reserves (Lukov u Moravských Budějovic, Číchov, etc.).
- Devonian of Barrandien, with the already exhausted classical deposit of pure dolomites Velká Chuchle.

- Orlicko-Kladsko crystalline complex and the Silesian Block (Velké Vrbno dome) with several smaller deposits of dolomites (Bílá Voda).
- Moravian (Čelechovice-Přerov) Devonian SW from Olomouc with two larger deposits (Hněvotín, Bystročice) of Lažánky limestone dolomites, which appear here together with Vilémovice limestones. The average Mg contents in both deposits are around 17%. Further SW there is a medium-sized deposit of Lažánky limestone dolomites Čelechovice of similar composition (reserves bound by the protective zone of the spa).

The most important are the areas of the Krkonoše-Jizera crystalline complex and the Moravian Devonian, where dolomites (Lánov, Hněvotín) partially occur in some deposits, but they are mostly calcareous dolomites. The Šumava Moldanubian deposits are mostly smaller or are formed by low-purity calcareous dolomites. In other areas, dolomites form only smaller lenses and are often insufficiently explored (especially in western Moravia).

3. Registered deposits and other resources of the Czech Republic



Principal areas of deposits presence

*(Names of exploited deposits are in **bold type**)*

1 **Bohdaneč**	5 Hněvotín	9 Kryštofovo Údolí
2 **Lánov**	6 Horní Rokytnice	10 Křížlice
3 Bystročice	7 Jesenný-Skalka	11 Machnín-Karlov pod Ještědem
4 Čelechovice na Hané	8 Koberovy	12 Podmokly

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	12	12	12	12	11
exploited	2	2	2	2	1
Total mineral *reserves, kt	525,046	524,595	524,142	522,028	522,635
economic explored reserves	83,536	83,087	82,643	80,529	80,136
economic prospected reserves	348,288	348,286	337,297	337,297	337,297
potentially economic reserves	93,222	93,222	104,202	104,202	104,202
exploitable (recoverable) reserves	10,429	9,979	9,526	7,526	7,132
Mine production, kt	450	451	453	398	393

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	23 946	23 946	23 946	23 946	23 946
P_2		–	–	–	–	–
P_3		–	–	–	–	–

5. Foreign trade

2518 – Dolomite calcined, roughly trimmed or cut; agglomerated

		2017	2018	2019	2020	2021
Import	t	452,305	526,570	443,075	485,996	476,715
Export	t	133	131	58	73	105

2518 – Dolomite calcined, roughly trimmed or cut; agglomerated

		2017	2018	2019	2020	2021
Average import prices	CZK/t	252	232	227	235	233
Average export prices	CZK/t	5,747	3,282	5,472	9,651	6,352

6. Prices of domestic market

Average domestic prices of traded commodities

Product specification	2017	2018	2019	2020	2021
Dolomite aggregates, CZK/t	406–499	300–470	318–376	325–387	320–430
Ground calcitic dolomite, bulk, CZK/t	729	729	770–830	780–850	840
Ground calcitic dolomite, bagged, CZK/t	1,675–1,800	1,800	1,900–2,060	1,950–2,100	2,200

7. Mining companies in the Czech Republic as of December 31, 2021

Krkonošské vápenky Kunčice, a.s.

8. World production and world market prices

World mine production

World dolomite production is not listed in the statistics. Even though dolomite is considered to be a main potential source of magnesium in the lithosphere, it is currently not used for the production of magnesium. Otherwise, calcined dolomite with a minimum magnesium content of 8% is suitable for this purpose.

World dolomite prices are not included in international overviews.

Feldspar

1. Characteristics and use

Feldspar raw materials are rocks whose characteristic component is one of the minerals from the feldspar group or a mixture thereof in such a form, quantity and quality that it can be extracted industrially. Feldspars are a group of monoclinic (orthoclase $KAlSi_3O_8$, sanidine) and triclinic (microcline $KAlSi_3O_8$ and plagioclase) potassium and sodium-calcium aluminosilicates. Together with quartz, they are the most widespread rock-forming minerals, which together make up 60% of the earth's crust. Potassium (K) feldspars are of industrial importance – orthoclase, microcline and acidic (with a predominance of Na over Ca) members of the plagioclase family (albite $NaAlSi_3O_8$, oligoclase, andesine). Alkaline (with a predominance of Ca over Na) members of the plagioclase series (labradorite, bytownite, anorthite $CaAl_2Si_2O_8$) are of marginal importance. Vein rocks (pegmatites, aplites), igneous rocks (leucocratic granitoids) and sediments (feldspar sands and gravels) are mainly used as feldspar raw materials, as well as residues of incompletely kaolinised rocks and metamorphites. The main pollutants are a high proportion of iron in the feldspar lattice (untreatable) and impurities (treatable).

Reserves

2021		
Země	**kt**	**% svět****
Iran	630,000	N
India	320,000	N
Thailand	240,000	N
Turkey	220,000	N
South Korea	180,000	N
Brazil	150,000	N
Czech Republic*	54,000	N
World	**N**	**N**

** Bilance zásob k 1. 1. 2022 (national Register of Reserves as of 1. 1. 2022, rounded)*
*** Total world reserves are large but not quantified*
Source: MCS 2022

2021			
Země	**mill t**	**% svět**	**% EU**
EU	154,000	5.40	100.0
Czech Republic*	54,000	1.90	56.5
Romania	22,000	0.80	14.3
Slovakia	22,000	0.80	14.3
Spain	17,000	0.60	11.0
Poland	5,000	0.20	3.2
Italy	1,000	0.04	0.6

** Bilance zásob k 1.1.2021 (national Register of Reserves as of 1. 1. 2022)*
Source: European Minerals Yearbook – version 2021

Uses

Due to their low melting point, feldspars are used as a flux in ceramic mixtures, glass stem, glazes, enamels and in recent years also as casting powders in metallurgy. Almost 90% of feldspars are consumed by the glass and ceramic industries. A small amount is also used as a filler, especially in paints and plastics. Feldspar substitutes are also used in glassmaking. In addition to feldspar raw materials, rocks that have an alkali content bound to another mineral (mostly nepheline $Na_3K(Al_4Si_4O_{16}$ – anhydrous sodium-potassium aluminosilicate) are used as their substitutes. In the world, nepheline syenites are mainly used, and to a lesser extent also nepheline phonolites.

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

In the Czech Republic, deposits of feldspar raw materials are connected to primary sources, consisting mainly of leucocratic granitoids and pegmatite bodies. Secondary sources are represented by feldspar gravels and sands.

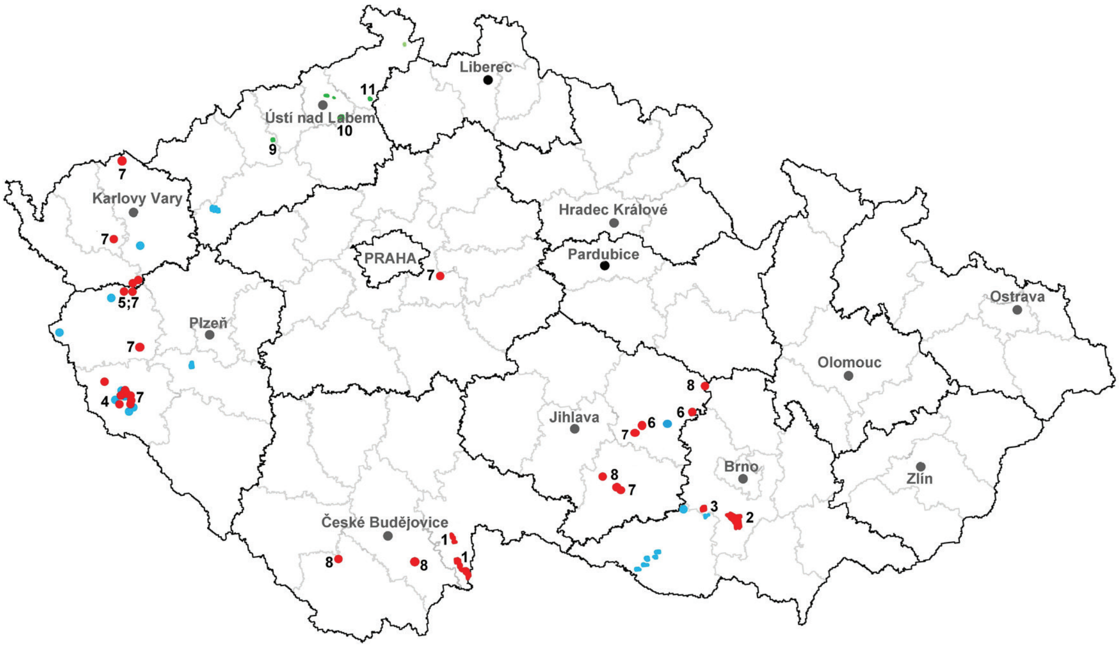
- An important source of feldspar raw materials are currently the deposits of fluvial Quaternary feldspar placers, which make up 36% of geological reserves. They were formed by the deposition of desintegrated granite rocks with mostly high content of porphyric phenocrysts, mostly potassium feldspars. The following two areas are the most important:
    1) The upper course of the Lužnice River with deposits Halámky, Krabonoš, Tušť, Dvory nad Lužnicí, Majdalena, among which the mined deposit Halámky is decisive, the remaining deposits are not mined. The Halámky deposit mined from water is one of the most important sources of quality feldspars in the Czech Republic and the most important representative of the secondary type of deposits – feldspar gravel sands. A large part of the reserves of these deposits is linked to conflicts of interest with nature protection, especially with the Třeboňsko Protected Landscape Area. The Lužnice gravel sands account for less than 19% of the total geological reserves of feldspar raw materials.
    2) The area south of Brno with deposits of the Jihlava River – the Syrovice-Ivaň terrace with deposits Bratčice, Žabčice-Smolín, Hrušovany, Ledce, etc. has a slightly worse feldspar quality – higher Fe contents. However, the vast majority of the local raw material is currently used only as construction gravel, only a part has been deposited in dumpings since 2000 for later use as feldspar raw material. Similar deposits of feldspar accumulations of the Jihlava River are in the vicinity of Ivančice southwest of Brno. Together, they make up about 17% of the geological reserves of feldspar raw materials.

The raw material of fluvial deposits are feldspar gravels with a predominance of potassium feldspars over plagioclase, suitable for the production of utility porcelain, medical ceramics, glass, etc. and, to a limited extent, for the production of glazes.

- The importance of fine to medium-grained leucocratic granitoids (granites and granite aplites, quartz diorites) is constantly growing, currently accounting for almost 50% of all domestic geological reserves of feldspar raw materials. Due to the dimensions of the granitoid bodies, the deposits are often medium to larger in size and the raw material is usually of relatively high quality. They are developed, for example, in the Krušné hory pluton in western Bohemia, where the most important and largest domestic deposit Krásno is quarried (albitic aplitic granite), the Mračnice massif (Mračnice: quartz diorite-trondhjemite), the Třebíč massif (Velké Meziříčí-Lavičky: aplitic granite, Mikulovice and Výčapy: tourmaline granite). They were also explored in other massifs, such as Brno (Moravský Krumlov), Dyje (Přímětice), Chvaletice, Blanice, Babylon, Kladruby (Benešovice), partial massifs of the Central Bohemian pluton, etc. The raw material consists mostly of sodium-potassium feldspars and is used in the production of sanitary ceramics, stained glass, porcelain, grinding wheels, etc.

- Coarse-grained to porphyric leucocratic granitoids could represent a significant source of feldspar raw material in the future, currently accounting for about 6.5% of total reserves. Deposits and sources form relatively large bodies, but often with a lower quality of raw material (increased Fe contents). They are known in the massifs of Říčany (Štíhlice), Čistec-Jesenice, Bor, Krkonoše-Jizera pluton (Liberec granite), Lestkov (Hanov), etc. The raw material consists mostly of sodium-potassium feldspars and to reduce the Fe content it is usually necessary to treat it with high-intensity magnetic separation.
- In the past, the pegmatite deposits known from several areas were the only source of raw material used mainly for ceramics. The deposits are mostly smaller, which is caused by the limited range of pegmatite bodies and they account for only 8% of the total reserves. The most important is the Poběžovice-Domažlice area with the mined Luženičky deposit and other, currently unmined deposits and resources (e.g. Meclov, Mutěnín, Ohnišťovice, Otov, Bozdíš) with pegmatites of medium to worse quality with an admixture of dark minerals, which have a balanced ratio of sodium and potassium. feldspars. However, there are also deposits of quality sodium and sodium-calcium feldspars for glazes and clear glass (Ždánov). In other areas, potassium feldspars predominate in pegmatites. In the Teplá region in western Bohemia, there are relatively abundant occurrences of relatively high-quality feldspars with low contents of pollutants (Beroun, Křepkovice, Zhořec). Recently, the relatively little explored area of Písek is perhaps promising. Some smaller occurrences and deposits are known from the vicinity of Humpolec, Tábor, Rozvadov (Česká Ves), from western Moravia (Smrček), etc. Due to the irregularity of the deposit bodies, small and largely extracted reserves, but also conflicts of interest, feldspars from pegmatites are no longer a very promising source. A large part of the highest quality raw material of pegmatite deposits (mainly in the Poběžovice-Domažlice and Písek areas) is considerably depleted by mining, especially in the more easily accessible subsurface areas. This also applies to the area of the Bory granulite massif with a small Bory-Olší deposit, following the classic exhausted Dolní Bory deposit.
- Recently, deposits of feldspar raw materials forming lenses in metamorphic rocks have been newly investigated. The orthoclasite to microclinite deposit Markvartice near Třebíč is situated in the western branch of the variegated group of the Moravian Moldanubicum. The Malá Tresná albitite deposit lies on the NW edge of the Svratka dome of the Moravicum at the junction of the micaschist zone and the Olešnice group. The Chvalšina deposit of anorthosite to gabbro is deposited in the amphibolites of the Český Krumlov variegated group of the Šumava Moldanubicum.
- Another potentially promising source of feldspar raw material may be the kaolinised feldspar rocks with undecomposed or imperfectly decomposed feldspars. These are mainly arkoses in the Plzeň and Podbořany areas, gneisses and granitoids in the Znojmo area (see the chapter Kaolin – feldspar kaolin).
- Tertiary volcanics – nepheline phonolites – of the České středohoří Mts. are used as feldspar substitutes in the Czech Republic (Želenice deposit). Due to the high contents of colouring oxides, they can be used in the glass and ceramic industry only as a flux for coloured materials. The high alkali content (10–10.5% Na_2O and 3.5–5% K_2O) makes it possible to reduce melting temperatures and shorten the burning time.

3. Registered deposits and other resources of the Czech Republic



- reserved registered deposits
- exhausted deposits and other resources
- feldspar mineral substitutes (reserved registered exploited deposit and and other resources)

The main deposit areas of feldspar raw material

*(Names of exploited deposits are in **bold type**)*

1 **Sediments of the Lužnice River region**
2 **Sediments of the Jihlava River (the Syrovice-Ivaň Terrace)**
3 Sediments of the Jihlava River) (the Ivančice region)
4 **Pegmatites (the Poběžovice-Domažlice region)**
5 Pegmatites (the Teplá region)
6 Pegmatites (the western Moravia region)
7 **Granitoids**
8 Others

Feldspar mineral substitutes (nepheline phonolites):

9 **Želenice**
10 Tašov-Rovný
11 Valkeřice-Zaječí vrch

4. Basic statistical data of the Czech Republic as of December 31

Feldspar
Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	39	40	41	42	42
exploited	9	9	10	10	10
Total mineral *reserves, kt	76,063	91,722	101,487	102,853	102,324
economic explored reserves	24,415	28,709	29,742	29,334	28,846
economic prospected reserves	36,162	47,157	55,889	57,663	57,622
potentially economic reserves	15,698	15,856	15,856	15,856	15,856
exploitable (recoverable) reserves	22,872	22,596	22,126	21,599	29,709
Mine production, kt	368	449	460	419	504

** See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	48 530	48 530	48 530	48 530	48 530
P_2		–	–	–	–	–
P_3		–	–	–	–	–

Number of deposits; reserves; mine production
Feldspar substitutes (nepheline phonolites)

Year	2017	2018	2019	2020	2021
Deposits – total number	3	3	3	3	3
exploited	1	1	1	1	1
Total mineral *reserves, kt	199,773	199,773	199,709	199,709	199,107
economic explored reserves	0	0	0	0	0
economic prospected reserves	199,773	199,742	199,709	199,680	199,656
potentially economic reserves	0	0	0	0	0
exploitable (recoverable) reserves	24,203	24,173	24,140	24,111	24,086
Mine production, kt	34	31	33	29	24

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1		–	–	–	–	–
P_2,	kt	30 300	30 300	30 300	30 300	30 300
P_3		–	–	–	–	–

5. Foreign trade

252910 – Feldspar

		2017	2018	2019	2020	2021
Import	t	9,373	10,831	7,225	5,607	6,634
Export	t	223,768	252,956	271,561	224,780	244,689

252910 – Feldspar

		2017	2018	2019	2020	2021
Average import prices	CZK/t	2,506	2,713	3,632	3,619	3,354
Average export prices	CZK/t	1,044	1,023	834	859	894

252930 – Leucite, nepheline and nepheline syenite

		2017	2018	2019	2020	2021
Import	t	3,421	3,777	4,524	4,207	4,552
Export	t	2	3	482	543	759

252930 – Leucite, nepheline and nepheline syenite

		2017	2018	2019	2020	2021
Average import prices	CZK/t	6,315	6,264	6,488	6,680	6,562
Average export prices	CZK/t	9,114	9,017	10,866	11,071	10,345

6. Prices of domestic market

Feldspars were sold domestically for CZK 1,500–5,500 per tonne in 2021 depending on their chemism and usage

7. Mining companies in the Czech Republic as of December 31, 2021

Feldspar
KMK GRANIT, a.s., Krásno
LB MINERALS, s.r.o., Horní Bříza
Družstvo DRUMAPO, Němčičky
Moravia Tech, a.s., Brno

Feldspar substitutes
KERAMOST, a.s., Most

8. World production and world market prices

World mine production

The data on world feldspar production and on the production of countries from various sources differ considerably. Estimates of Chinese feldspar production differ the most. The lowest total data are given in the Mineral Commodity Summary (MCS), which, for example, does not mention Germany at all among the world's leading feldspar producers. MCS provides data for feldspar and nepheline syenite. Higher global mining is reported by the yearbook World Mineral Production (WMP), published by the British Geological Survey. Probably the most accurate figures are given in the Austrian yearbook Welt Bergbau Daten (WBD).

Year	2017	2018	2019	2020	2021[e]
World mine production of feldspar (according to MCS), kt	24,700	25,600	23,000	24,400	28,000
World mine production of feldspar (according to WBD), kt	31,489	35,050	31,054	30,902	N
World mine production of feldspar (according to WMP), kt	29,762	31,970	30,382	30,317	N

e – preliminary values

Main producers according to MCS

2021[e]		
Country	**kt**	**%**
Turkey	7,800	27.9
India	6,200	22.1
China	2,600	9.3
Iran	2,400	8.6
Italy	2,200	7.9
Thailand	1,300	4.6
Spain	800	2.9
Mexico	500	1.8
Czech Republic	420	1.5
Korea, Republic of	420	1.5
World	**28,000**	**100.0**

e – preliminary values

Prices of traded commodities (according to IM)

Commodity/year		2017	2018	2019	2020	2021
Feldspar, marketable production, US market, average price, according to MCS	USD/t	64	97	107	108	110
Nepheline syenite, average US import price, according to MCS	USD/t	61	76	156	163	170
Feldspar for the ceramic and glass industry, average export price from the Czech Republic to Poland (CZSO)	EUR/t	37.96	38.24	27.99	26.77	28.48

Gemstones

1. Characteristics and use

Gemstones (gems) are natural materials that are suitable for use in jewellery. They can be minerals, rocks, natural glass and organic materials (e.g. pearls, amber, jet (a compact black variety of brown coal used to make (mourning) jewellery) or ivory). Their main properties are beauty (mainly interesting colour, type of cutting, etc.), durability (hardness, toughness) and rarity. Gems used to be sorted by hardness (diamond, corundum, chrysoberyl, beryl, spinel, topaz,…), because the hardness of 7 or more is ideal for use in jewellery. Today, a mineralogical system is used according to its chemical composition – the most important gems are elements (diamond), oxides (corundum, spinel, chrysoberyl, quartz, etc.) and silicates (beryl, tourmaline, topaz, etc.). In terms of origin and geological environment, gems are found in volcanites (diamond, corundum, olivine, amethyst in geodes), pegmatites (beryl, tourmaline, topaz, chrysoberyl, rose quartz), hydrothermal veins (emerald, quartz), metamorphites (corundum, spinel, emerald) and sediments (almost all the listed ones after erosion of the original parent rocks).

Gemstones are a raw material that is completely different from the others listed in this yearbook. This is due to the extreme range of their price depending on the quality. The old division into precious and semi-precious stones is also no longer used in modern literature, because, for example, high-quality amethyst can be more expensive than low-quality ruby or emerald. Rather, the division into gemstones (used cut in jewellery) and decorative stones (e.g. agate, malachite, etc., usually used only polished). Waste after gem processing can in some cases (mainly garnets and corundum) be used as an abrasive.

Technically, it is necessary to divide the stones in the jewellery into the following four categories:

1. natural stones, completely untreated
2. natural stones modified by men (e.g. high-temperature firing, radioactive irradiation, filling of cracks with a foreign substance, artificial colouring and many others are used)
3. synthetic stones (same properties as natural stones)
4. imitations (e.g. glass, different properties than natural stones)

The problem is that only an experienced expert with very good instrumentation can correctly identify a gemstone and place it in these categories, and new treatment procedures appear every year. The differences in price are huge.

There are treatments that significantly improve the appearance of the stone, and which logically must have a lower price than the same natural stones. Synthetic cut diamonds are also common on the market today (so far mainly coloured, colourless are much harder to produce) and their share will increase rapidly in the future. It is necessary to emphasise that these are stones that may seem very similar to a layman.

Reserves

There are not listed.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

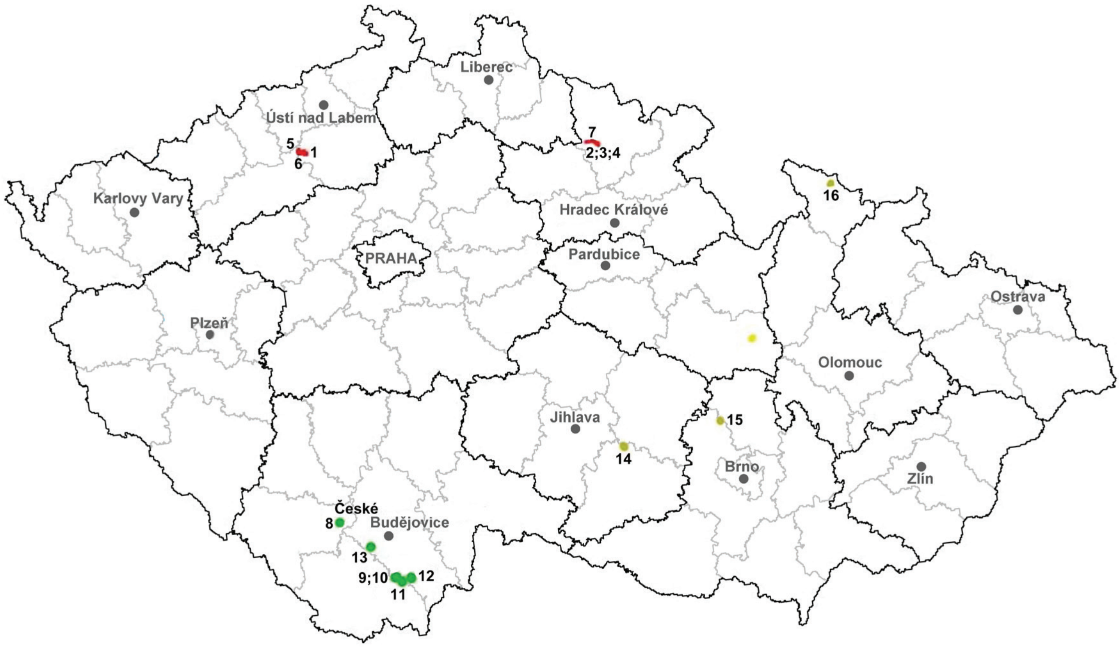
2. Mineral resources of the Czech Republic

Although the Czech Republic is geologically very complex and therefore rich in various types of deposits, it is very poor in gemstones. Only deposits of pyrope (Czech garnet) and moldavites are of international importance; the occurrences of some decorative quartz (crystals and smoky quartz in pegmatites around Velké Meziříčí and Liberec), agates in the foothills of Krkonoše Mts., amethyst and jasper in the Ore Mountains, porcelainite (originally clay minerals burned in contact with basalt) in southern Moravia, opals in the vicinity of Křemže in southern Bohemia, etc. are economically insignificant.

Pyrope is a mineral from the group of garnet with a composition of $Mg_3Al_2[SiO_4]O_3$, but always with an admixture of Fe and dyed with Cr. The world's most famous blood-red pyrope gemstone is the Czech garnet, mined for several centuries in Quaternary gravels at the foot of the České středohoří Mts. Their parent rock are the ultrabasic xenoliths (enclosures) in Tertiary volcanites. At present, the Podsedice deposit is being mined and the small Vestřev deposit in Podkrkonoší is already exhausted. The content of pyropes over 2 mm in the raw material is fluctuating and usually ranges between 20 and 100 g per 1 ton of rock. Real Czech garnets are always small; raw stones with a diameter of over 5 mm are infrequent and those over 7 mm are rare. Therefore, in jewellery, much larger and more abundant almandine garnets imported from abroad are used as central stones, but they have a brownish or purple hue.

A completely unique Czech gem is the moldavite, which belongs to the tektites. Tektites are natural glasses that occur in several places around the world. Their formation has always been a mystery, but at present the prevailing opinion is that they are terrestrial rocks that were remelted during the fall of a large meteorite and the melt sprayed over a long distance. For most of the world's tektites, we have also been able to identify the crater where the meteorite landed. The moldavites originate from the Ries crater near the German city of Nördlingen in Bavaria and were formed about 15 million years ago. They are located in southern Bohemia in Tertiary and Quaternary alluviums, mainly south of České Budějovice. They are characterised by a green colour and an uneven surface with many grooves, which were created by natural etching. Moldavites are usually 1 to 3 cm in size, larger ones are rare. They are used in jewellery either in their natural state or cut. There are smaller occurrences of moldavites in southern Moravia around Třebíč, but there they have an unattractive brown-green colour and are unusable as gems. Several small deposits were and are mined in southern Bohemia. The content of moldavites in deposits is very variable and usually ranges between 8 to 15 g per 1 m^3 (5 to 8 g per 1 ton) of rock.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits of pyrope-bearing rock
exhausted deposits and other resources of pyrope-bearing rock
reserved registered deposits of moldavite-bearing rock
exhausted deposits and other resources of moldavite-bearing rock
reserved registered deposits of other gemstones
exhausted deposits and other resources of other gemstones

Pyrope-bearing rock:	Moldavite-bearing rock:	Other gemstones:
1 **Podsedice-Dřemčice**	8 Hrbov u Lhenic	14 Bochovice *
2 Vestřev	9 **Chlum nad Malší-východ**	15 Rašov **
3 **Dolní Olešnice**	10 **Ločenice-Chlum**	16 Velká Kraš ***
4 Horní Olešnice 1	11 Besednice	
5 Horní Olešnice 2	12 Slavče-sever	
6 Linhorka-Staré	13 Vrábče-Nová Hospoda	
7 Třebívlice		

*(Names of exploited deposits are in **bold type**)*

* *amethyst,*
** *opal,*
*** *gem varieties of quartz*

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number a)	13	12	15	15	15
exploited b)	3	3	4	4	2
Total mineral *reserves, kt a)	19,366	19,353	19,359	19,357	19,357
economic explored reserves	3,183	3,170	3,162	3,161	3,161
economic prospected reserves	13,002	13,002	13,016	13,016	13,016
potentially economic reserves	3,181	3,181	3,181	3,180	3,180
exploitable (recoverable) reserves	24,203	29,562	29,551	29 549	1,099
Total mineral *reserves, m^3 c)	434,592	373,202	1,466,041	1,415 330	1,372,017
economic explored reserves	43,025	36,352	26,352	21,352	9,352
economic prospected reserves	388,468	333,751	1,434,478	1,393 978	1,357,454
potentially economic reserves	3,099	3, 099	5,211	5,211	5,211
exploitable (recoverable) reserves	291,406	167,235	281,317	235,817	187,293
Total mineral *reserves, kt (1 m^3 = 1.8 t) c)	782	671	1,465	2,556	1,371
economic explored reserves	77	65	47	38	9
economic prospected reserves	388	601	1,434	2,509	1,357
potentially economic reserves	6	6	9	9	5
exploitable (recoverable) reserves	692	323	506	236	187
Mine production, kt a)	34	13	12	1	0
Mine production, ths m^3 c)	54	61	42	46	49
Mine production, kt c) (1 m^3 = 1.8 t)	97	110	76	83	88

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

a) pyrope-bearing rock

b) in 2016–2017 one deposit of pyrope and three deposits of moldavite, in 2018 one deposit of pyrope and two deposits of moldavite, in 2019–2020 two deposits of pyrope and two deposits of moldavite

c) moldavite-bearing rock

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P1,	[b] kt	749	749	749	749	749
P1,	[c] ths m^3	66	66	66	66	66
P1,	[c] kt	118	118	118	118	118
P2,	[a] t	100	100	100	100	100
P3		–	–	–	–	–

Notes: [a] jasper, [b] pyrope-bearing rock, [c] moldavite-bearing rock

5. Foreign trade

7102 – Diamonds, whether or not worked, but not mounted or set

		2017	2018	2019	2020	2021
Import	kg	9,157	15,341	30,097	18	1,011
Export	kg	155	109	5	39	34

7102 – Diamonds, whether or not worked, but not mounted or set

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	25,234	15,163	7,393	16,246,944	309,815
Average export prices	CZK/kg	329,884	419,761	3,003,200	2,570,462	1 231,765

7103 – Precious (other than diamond) and semi-precious stones, whether or not worked or graded but not strung, mounted or set

		2017	2018	2019	2020	2021
Import	kg	151,617	343,708	374,073	115,537	422,193
Export	kg	71,058	87,394	45,644	78,985	176,699

7103 – Precious (other than diamond) and semi-precious stones, whether or not worked or graded but not strung, mounted or set

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	354	232	928	266	310
Average export prices	CZK/kg	729	613	1,575	1,021	591

251320 – Emery, natural corundum, natural garnet and other natural abrasives

		2017	2018	2019	2020	2021
Import	t	4,336	3,808	4,017	12,711	1,669
Export	t	213	182	276	147	139

251320 – Emery, natural corundum, natural garnet and other natural abrasives

		2017	2018	2019	2020	2021
Average import prices	CZK/t	7,266	7,944	7,810	8,367	8,813
Average export prices	CZK/t	53,849	47,414	10,350	12,860	23,950

6. Prices of domestic market

The international gemstone trade is currently so globalized that no substantial price differences exist anywhere in the world including the Czech Republic. The only difference is that rather lower-quality gemstones are imported due to lower purchasing power as well as to less experienced jewellers and customers; high-quality gemstones in the Czech market are rare.

Company Granát, cooperative of art manufacturing in Turnov, purchased Czech garnets (pyropes) under following conditions in 2021:

Purchase prices of raw Czech garnets by size classes

Class	Screen size (mm)	Minimum thickness (mm)	Price CZK/g
IV.	2.6–2.9 mm	2.6 mm	10 CZK /g
III.	3.0–3.9 mm	2.6 mm	20 CZK /g
II.	4.0–4.9 mm	3.0 mm	50 CZK /g
I.	5.0–5.9 mm	3.5 mm	120 CZK /g
E0 and bigger	from 6.0 mm and more	4.5 mm	from 250 CZK /g

In the year 2020 Company Granát bought for the jewelery processing also moldavites (solid, intact stones) weighing from 1g to 10g and bought also the moldavite raw material (broken stones and fragments) for the cutting in a weight of 1g above and a minimum material thickness of 5 mm.

The actual purchase price of moldavites, depending on the size and quality of the stones, ranges from 100 to 300 CZK per gram.

Internet wholesale NATURSHOP.cz offered moldavites in the following size–shape-number-price relations (each moldavite was packaged separately in a plastic box with its description):

Mine locality	Weight (g)	Number of pieces	Price (CZK)
Besednice *	1.50 – 2.05	1	1,290 – 1,650
	2.14 – 2.74	1	1,720 – 2,200
	2.90 – 3.10	1	2,320 – 2,480
	3.03 – 3.08	1	2,450 – 2,460
	3.40 – 3.47	1	2,720 – 2,960
	3.57 – 3.62	1	2,890 – 2,900
	4.08	1	3,280
Chlum	3.47 – 3.68	1	1,920 – 2,050
	3.87 – 3.92	1	2,150 – 2,160
	4.14 – 4.97	1	2,290 – 2,750
	5.20 – 5.35	1	3,150 – 3,200
	5.51 – 5.35	1	3,220 – 3,240
	5.51 – 5.90	1	3,430 – 3,650
	6.70	1	4,020

*Note: * moldavites from this locality are visually regarded as the best*

7. Mining companies in the Czech Republic as of December 31, 2021

Pyrope-bearing rock
Granát, družstvo umělecké výroby, Turnov

Moldavite-bearing rock
MAWE CK s.r.o., Český Krumlov

8. World production and world market prices

World production

Statistical data on gem-quality garnet production are not available. MCS overviews provide the following data on global production of industrial garnets whose world's largest producers include Australia, China, South Africa, India and the USA in recent years:

	2017	2018	2019	2020	2021^e
World production, t	1,250,000	1,120,000	1,100,000	1,100,000	1,100,000

e – preliminary value

World statistics include principally diamond mining, both gem-grade and industrial ones.

World gem-grade diamond production was as follows
(in ths ct (ct = carat; 1 ct = 0.2 g):

	2017	2018	2019	2020	2021^e
World mine production (according to WBD)	80,553	82,829	77,724	62,013	N
World mine production (according to MCS)	88,100	89,000	82,400	62,300	63,000

e – preliminary values

Main producers according to MCS

2021^e		
Gem-quality diamonds		
Country	**ths carats**	**%**
Russia	18,000	28.6
Canada	13,000	20.6
Botswana	12,000	19.0
Angola	7,100	11.3
South Africa	6,900	11.0
Congo (Kinshasa)	2,600	4.1
Namibia	1,600	2.5
Sierra Leone	520	0.8
Lesotho	490	0.8
Zimbabwe	270	0.4
World	**63,000**	**100.0**

e – preliminary values

2021^e		
Industrial diamonds		
Country	**ths carats**	**%**
Russia	15,000	33.3
Congo (Kinshasa)	11,000	24.4
Australia	8,000	17.8
Botswana	6,000	13.3
South Africa	2,000	4.4
Zimbabwe	1,000	2.2
others	1,000	2.2
World	**45,000**	**100.0**

e – preliminary values

World production of industrial diamonds was as follows:

	2017	2018	2019	2020	2021e
World production (according to WBD), ths ct	70,196	64,589	57,633	46,164	N
World production (according to MCS), ths ct	63,000	58,000	55,000	45,000	45,000

e – preliminary values

World market prices

Gemstone prices depend on the type, size, and quality of the stones while the price ranges are considerable.

According to https://www.creditdonkey.com/diamond-prices.html, the following price points indicate the current prices of gem-quality diamonds and the recommended values for the best price-quality/beauty ratios of gem-quality diamonds in 2020. The prices quoted are for round diamonds. Other diamond shapes cost up to 20–40 % less than round diamonds.

Carat Weight	Diamond Price USD/ct	Total Price USD/ct	Recommended Price USD/ct
0.25	800–4,000	200–1,000	300–450
0.50	1,000–8,000	500–4,000	1,000–1,500
0.75	1,300–9,000	1,000–6,800	2,000–3,000
1.0	2,000–16,000	2,000–20,000	4,500–6,000
1.5	2,670–20,000	4,000–30,000	8,000–10,000
2.0	4,000–35,000	8,000–70,000	18,000–21,000
3.0	7,000–66,700	20,000–200,000	40,000–50,000

Commodity/year	2017	2018	2019	2020	2021
Industrial diamonds, US import, USD/ct (according to MCS)	12.90	2.90	3.90	7.40	12.00
Industrial garnets, US import, USD/t (according to MCS)	305	215	214	250	325

Gypsum

1. Characteristics and use

Gypsum is a sedimentary rock composed mainly or completely of the gypsum mineral ($CaSO_4.2H_2O$), which is usually colourless to white. The rock is often contaminated with impurities (clayey, sandy, ferrous, limestone, dolomite, anhydrite, etc.). The vast majority of gypsum deposits were formed by evaporation of sea or lake water and subsequent crystallisation of gypsum (often with anhydrite) in arid areas. Deposits formed by other means (e.g. hydration of anhydrite, decomposition of sulphides, metasomatic, etc.) are of little importance. Anhydrite (anhydrous $CaSO_4$) is often classified as gypsum. It is usually converted into gypsum by wet grinding.

Reserves

They are extensive worldwide.

Uses

Gypsum is most often used in the manufacture of building materials – the production of gypsum, cement, plasters and prefabricated parts – and in small quantities for other purposes (in agriculture, in the production of glass, paper, in pharmacy and also as a filler). At present, energy gypsum is used rather than natural gypsum, which is a product of desulphurisation, especially of coal flue gases.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

Gypsum deposits in the Czech Republic are bound to Miocene (Baden-Wieliczkien) sediments of the Opava Basin (marginal part of the Carpathian foredeep) – most of the productive Baden lies on the Polish side. The average gypsum content in the raw material is 70–80%. Clays and sands are the main pollutants. The surface parts of the deposits are often affected by karsting. Mining (in the past also deep) of gypsum in the Opava region was taking place almost continuously in various localities since the middle of the 19th century. At present, only one deposit is surface mined (pit quarry) – Kobeřice in southern Silesia. After 1994, mining began to decline sharply, and after 2000, it stabilised at around 5 to 10% of the mining volume in the 1980s and 1990s. The main reason is the high production of energy gypsum, arising from the desulphurisation of power plants and heating plants.

3. Registered deposits and other resources of the Czech Republic

reserved registered deposits — exhausted deposits and other resources

1 **Kobeřice ve Slezsku-jih**	3 Rohov-Strahovice	5 Třebom
2 Kobeřice ve Slezsku-sever	4 Sudice	

*(Names of mined deposits are indicated in **bold type**)*

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	5	5	5	5	5
exploited	1	1	1	1	1
Total mineral *reserves, kt	503,168	504,160	504,159	504,133	504,116
economic explored reserves	118,041	119,033	119,022	119,006	118,989
economic prospected reserves	302,990	302,990	302,990	302,990	302,990
potentially economic reserves	82,137	82,137	82,137	82,137	82,137
exploitable (recoverable) reserves	2,200	2,192	2,181	43,652	43,635
Mine production, kt	7	6	10	17	17

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

5. Foreign trade

252010 – Gypsum, anhydrite

		2017	2018	2019	2020	2021
Import	t	59,069	76,116	79,423	95,403	163,223
Export	t	81,208	72,136	105,680	209,012	174,689

252010 – Gypsum, anhydrite

		2017	2018	2019	2020	2021
Average import prices	CZK/t	2,236	2,048	2,167	1,853	1,137
Average export prices	CZK/t	45	30	131	372	293

6. Prices of domestic market

Average prices of traded commodities on the domestic market

	2017	2018	2019	2020	2021
mined gypsum, CZK/t	N	N	N	N	N
grey gypsum binder, bagged in 30 kgs, pallets, CZK/t	3,672	3,672	4,507	4,625–4 820	4,660–4 860
white gypsum binder, bagged in 30 kgs, paliets, CZK/t	6,210	6,210	7,627	6,100–8 425	7,540–10 690

7. Mining companies in the Czech Republic as of December 31, 2021

GYPSTREND s.r.o., Kobeřice

8. World production and world market prices

World mine production

Data on world production of primary gypsum in recent years:

	2017	2018	2019	2020	2021[e]
World mine production of gypsum (according to MCS), kt	141,000	150,000	148,000	144,000	150,000
World mine production of gypsum (according to WBD), kt	155,849	167,939	160,136	161,909	N

e – preliminary values

Main producers according to MCS

2021^{e}		
Country	**kt**	**%**
USA	23,000	15.3
Iran	16,000	10.7
China	13,000	8.7
Spain	11,000	7.3
Oman	10,000	6.7
Thailand	9,800	6.5
Turkey	9,300	6.2
Mexico	5,400	3.6
Germany	4,500	3.0
Japan	4,300	2.9
Russia	4,200	2.8
Saudi Arabia	3,300	2.2
Canada	2,900	1.9
World	**150,000**	**100.0**

e – preliminary values

World market prices

There are no global indicative prices of gypsum. The Mineral Commodity Summaries (MCS) publishes US market prices, which have long ranged from $ 7 to $ 9 / t for raw gypsum with FOB delivery and to $ 30 to $ 35 / tonne for calcined gypsum with FOB delivery.

Industrial sands

1. Characteristics and use

Industrial sands is a common term for glass and foundry sands. These are quartz sands, which often occur in their deposits together.

Glass sands are granular light to white sedimentary rocks (quartz sands or sandstones), which are used after treatment as a raw material for glass production. Requirements for their quality (grain size, mineral and chemical composition) vary according to the type of glass produced. Sands of the required quality do not usually occur in nature, so it is necessary to modify them by crushing, washing (removal of washable particles) and sorting (achieving the required grain size). In the production of higher quality raw materials, it is necessary to reduce the contents of colouring oxides (Fe_2O_3, TiO_2, Al_2O_3) by more demanding methods of treatment (electromagnetic separation, flotation, etc.); the maximum SiO_2 content is also required. Melting glass sands are used for the production of glass bath for the production of flat, packaging and some technical glasses (max. contents of Fe_2O_3 0.023 to 0.040%), utility glass (up to 0.021% Fe_2O_3); higher quality types of glass sands are used for the production of opaque quartz glass (max. 0.020% Fe_2O_3) and the best ones (max. 0.012 to 0.015% Fe_2O_3) are used for crystal, semi-optical and some technical glasses.

Foundry sands are granular light-coloured rocks that are suitable for the production of foundry moulds and cores either directly or after treatment. The main requirements for foundry sands are sufficient heat resistance, strength (depending on the quality and quantity of the binder component) and suitable grain size (medium grain size and regularity of grain size). Due to their variability, natural foundry sands are increasingly being replaced by synthetic sands, i.e. quartz sands, into which a specified amount of binder (usually bentonite) is mixed.

Reserves

They are not listed worldwide.

Uses

Natural quartz sands, after wet sorting and drying, are often dyed with inorganic pigments and used for plasters, roofing and other decorative purposes.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The largest and most important deposits of glass sands in the Czech Republic are concentrated in the Czech Cretaceous basin, the smaller ones are in the Cheb basin. Some potentially interesting areas of the Czech Cretaceous Basin are mainly unpromising for reasons of nature protection (e.g. Lusatian Mountains, Bohemian Paradise, Adršpachy-Teplice Rocks, etc.).

- The most important deposit in the Czech Republic is Střeleč in the Jizera facial area of the Czech Cretaceous basin. The mined raw material consists of weakly consolidated quartz sandstones of Coniacian age and its quality reaches world parameters. The Mladějov reserve deposit in Bohemia is assessed in its southern forecourt.

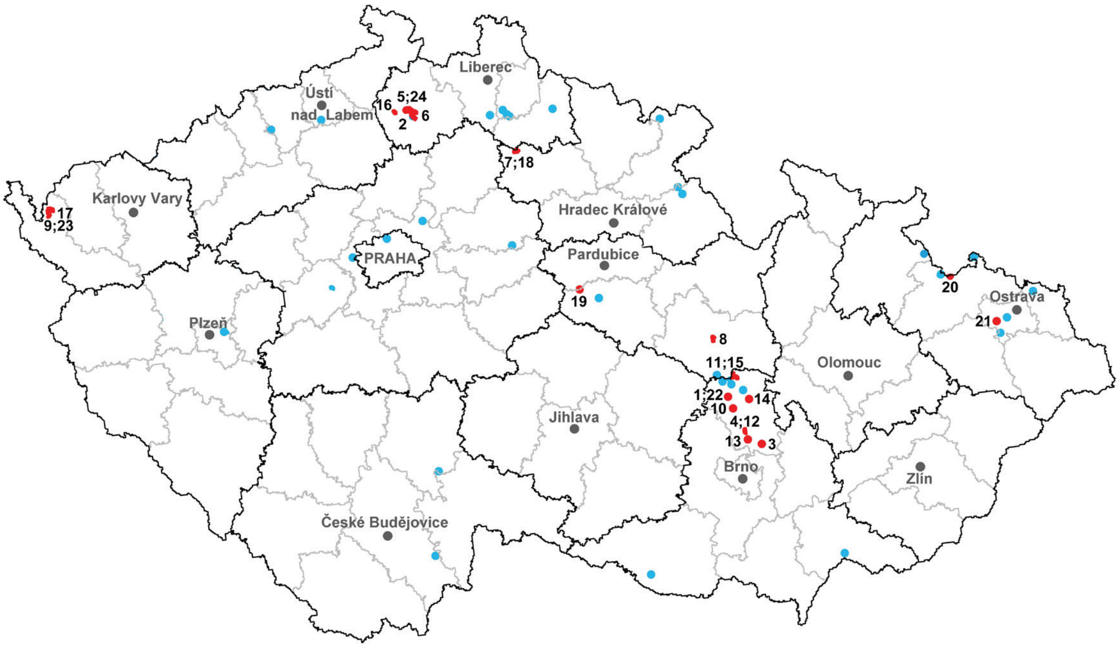
- The second most important area is the southern surroundings of Česká Lípa in the Lusatian facial area of the Czech Cretaceous basin. The raw material consists of weakly consolidated quartz sandstones of mid-Turonian age. The Provodín and Srní 2-Veselí deposits used until recently were exhausted in 2010 and 2015 respectively, and they were being gradually replaced by the Srní-Okřešice deposit since 2004, which has been the only mined deposit in the area since 2016.
- The non-traditional Velký Luh deposit is formed by the Pliocene gravels of the Cheb Basin (flooded material from kaolinically weathered Smrčina granite). The raw material is used for the production of technical, ceramic and water sands, most of the potentially economic raw material can be used as construction sand. The production of glass sands is not present here, because it would require a demanding treatment (abrasion, electromagnetic separation, grinding).

Foundry sand deposits accompany glass sands (lower quality raw material) on all deposits and they also occur separately. As in the case of glass sands, the deposits around Provodín and Střeleč are of the greatest importance.

- The third most important area is the Orlice-Žďár facial area of the Czech Cretaceous basin. The raw material consists of weakly consolidated Cenomanian quartz or glauconitic sandstones (natural sands). Mining is concentrated in the vicinity of Blansko, Voděrad and Svitavy.
- Glacigenic sands of northern Moravia (Palhanec-Vávrovice, Polanka nad Odrou), aeolian sands in the Elbe (Zvěřínek, Kluk) and southern Moravia (Bzenec, Strážnice, Břeclav), fluvial terrace sands of central (Tetín, Srbsko, exhausted Kobylisy-Dolní Chabry), southern (Lžín) and western Bohemia (Kyšice) and others, are currently of no interest due to low quality, demanding processing of raw materials and sufficient availability of better quality raw materials from other sources. The same applies to the sands of the Carpathian Neogene basins (Nový Šaldorf), etc.
- The sands of the Pliocene sediments of the Cheb Basin (Velký Luh) are of local importance.
- In addition, foundries sometimes use sands which are generated as waste during the floating of kaolins (e.g. Krásný Dvůr).

Deposits of glass and foundry sands in the Czech Republic are surface mined. Raw material of lower quality is used in construction.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

1 **Nýrov****
2 Provodín*
3 **Rudice-Seč****
4 **Spešov-Dolní Lhota****
5 **Srní-Okřešice***
6 **Srní 2-Veselí***
7 **Střeleč***
8 **Svitavy-Vendolí****
9 **Velký Luh***
10 **Voděrady****
11 Babolky**
12 Blansko 1-Jezírka**
13 **Blansko 2-Mošna****
14 Boskovice-Chrudichromy**
15 Deštná-Dolní Smržov**
16 Holany**
17 Lomnička u Plesné**
18 Mladějov v Čechách*
19 Načešice**
20 Palhanec-Vávrovice**
21 Polanka nad Odrou**
22 Rudka-Kunštát**
23 Velký Luh 1**
24 Zahrádky-Srní**

** deposits of glass and foundry sands*
*** deposits of foundry sands*

*(Names of exploited deposits are in **bold type**)*

4. Basic statistical data of the Czech Republic as of December 31

Glass sand
Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	6	6	6	7	7
exploited	4	3	4	3	3
Total mineral *reserves, kt	249,379	248,584	249,379	255,849	255,088
economic explored reserves	80,232	79,437	78,644	77,914	77,153
economic prospected reserves	24,415	24,415	29,970	29,970	29,970
potentially economic reserves	144,847	144,732	147,965	147,965	147,965
exploitable (recoverable) reserves	76,612	73,126	72,337	71,609	36,781
Mine production, kt	755	743	740	683	715

* *See <u>**NOTE**</u> in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	0	0	0	0	0
P_2,	kt	14,927	14,927	14,927	14,927	14,927
P_3		–	–	–	–	–

Foundry sand
Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	25	25	25	26	26
exploited	8	7	8	6	6
Total mineral *reserves, kt	409,489	405,205	409,489	405,761	405,160
economic explored reserves	126,323	125,757	125,227	124,748	124,162
economic prospected reserves	136,319	132,601	133,423	133,412	133,397
potentially economic reserves	146,732	146,847	147,601	147,601	147,601
exploitable (recoverable) reserves	76,612	76,034	73,378	72,891	4,374
Mine production, kt	556	559	514	470	583

* *See <u>**NOTE**</u> in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	15,157	15,157	15,157	15,157	15,157
P_2,	kt	14,723	14,723	14,723	29,650	29,650
P_3		–	–	–	–	–

5. Foreign trade

250510 – Silica sands and quartz sands

		2017	2018	2019	2020	2021
Import	t	263,278	252,101	500,006	257,395	299,888
Export	t	485,914	506,226	206,347	497,653	563,458

250510 – Silica sands and quartz sands

		2017	2018	2019	2020	2021
Average import prices	CZK/t	855	889	476	994	1,082
Average export prices	CZK/t	444	442	478	503	520

7001 – Cullet and other waste and scrap of glass; glass in the mass

		2017	2018	2019	2020	2021
Import	t	205,167	206,606	21,517	209,208	230,866
Export	t	29,191	21,204	21,517	15,357	27,188

7001 – Cullet and other waste and scrap of glass; glass in the mass

		2017	2018	2019	2020	2021
Average import prices	CZK/t	1,670	1,633	1,564	1,533	1,628
Average export prices	CZK/t	1,291	987	850	1,277	1,776

6. Prices of domestic market

Prices of foundry sands are not open to public, prices of glass sands are given in the range of CZK/t 150–2,500 in 2021.

7. Mining companies in the Czech Republic as of December 31, 2021

Glass sand
Sklopísek Střeleč, a.s., Mladějov
Provodínské písky a.s., Provodín
LB MINERALS, s.r.o., Horní Bříza

Foundry sand
Provodínské písky a.s., Provodín
Sklopísek Střeleč, a.s., Mladějov
LB MINERALS, s.r.o., Horní Bříza
Pískovna ŠAMŠULA a.s.
PEDOP s.r.o., Lipovec
Kalcit s.r.o.

8. World production and world market prices

World mine production

The published statistics on the production of industrial sand do not distinguish between glass and foundry sands. The large increase in the total volume of production by the MCS was due to the inclusion of the Netherlands mining, which has only occurred since 2017. Total production has developed as follows in recent years:

	2017	2018	2019	2020	2021^{e}
Industrial sands (according to MCS), kt	273,000	300,000	325,000	235,000	240,000

e – preliminary values

Main producers according to MCS

2021e		
Country	**kt**	**%**
USA	72,000	30.0
Netherlands	54,000	22.5
Turkey	12,000	5.0
India	12,000	5.0
France	11,000	4.6
Italy	10,000	4.2
Bulgaria	8,400	3.5
Spain	5,700	2.4
Poland	5,500	2.3
Canada	5,000	2.1
United Kingdom	4,400	1.8
Malaysia	4,000	1.7
Australia	3,500	1.5
World	**240,000**	**100.0**

e – preliminary values

Prices of traded commodities – silica sand

Commodity/year		2017	2018	2019	2020	2021
Silica sand for industrial use, average price, MCS	USD/t	52.10	56.10	46.10	30.70	33.00

Kaolin

1. Characteristics and use

Kaolin is most often a residual (primary), less often redeposited (secondary) white or light-coloured rock that contains a substantial amount of clay minerals from the kaolinite group. It always contains quartz, it can also contain other clay minerals, micas, feldspars and others depending on the nature of the parent rock.

Kaolin was most often formed by weathering or hydrothermal processes from various feldspar-rich rocks, most often granitoids, rhyolites, arkoses, gneisses, etc. These primary kaolins can be relocated, then they are secondary kaolins. The deposits are concentrated in the areas of occurrence of feldspar rocks, in which kaolinisation took place.

Reserves

They are extensive worldwide.

Uses

Most of the raw kaolin is treated in a dry or wet way to increase the content of the useful component (kaolinite). Treated kaolin is used for different purposes and different demands are placed on the raw material accordingly. Most kaolin is consumed in coatings and as a filler in the paper industry (around 45%) and also in the ceramics industry in the production of porcelain and other ceramics (around 20%). It is also used as a filler in rubber, plastics and paints, as optical fibre reinforcement, in the production of refractory materials, in the cosmetic, pharmaceutical and food industries. Kaolin is also the base material for the production of artificial zeolite. In the world, kaolin production is often ranked among clays.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The technological suitability of kaolin is assessed according to the properties of the obtained floated kaolin. In the Czech Republic, kaolins are divided according to their usability:

- Kaolin for the production of porcelain and fine ceramics – this is the highest quality kaolin with high requirements for purity, rheological properties, strength after drying, pure white baking colour ($Fe_2O_3 + TiO_2$ contents without treatment by high-intensity electromagnetic separation up to 1.2%), Al_2O_3 at least 33%.
- Kaolin for the ceramic industry – does not have precisely defined properties, it is used in various ceramic recipes. White and whitish baking colour, low contents of colouring oxides, etc. are appreciated.
- Kaolin for the paper industry – used as a filler in paper and as a coating – high whiteness in raw state and low abrasives content are required here. Furthermore, as a filler in rubber (low contents of “rubber poisons” are required here – Mn up to 0.002%; Cu up to 0.001%; and Fe up to 0.15%), plastics, glass fibres, etc.
- Titanium kaolin – has a TiO_2 content above 0.5% and occurs only in the Karlovy Vary region, where it originated from granites with a high content of Ti-minerals. Tests and

practices have shown in some cases the possibility of reducing the TiO_2 content by high-intensity electromagnetic separation, then part of these kaolins can be used as kaolin for the production of porcelain and fine ceramics, or as kaolin for the ceramic and paper industries.
- Feldspar kaolin – contains higher proportions of non-kaolinised feldspars, it is mainly used for the ceramic industry, especially for the production of sanitary and utility ceramics.

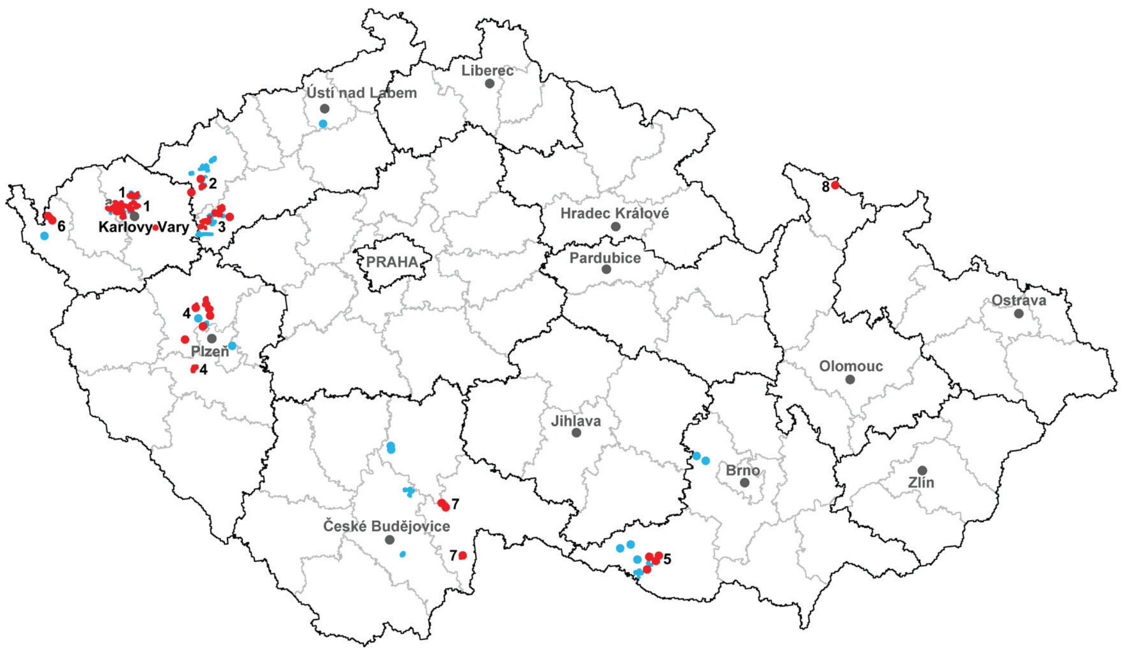
In the Czech Republic, all deposits were formed by kaolinic weathering of feldspar rocks. They are characterised by a decrease in kaolinisation with depth and a transition to unweathered parent rock. The absolutely predominant clay mineral is kaolinite. The main areas with kaolin deposits are:
- Karlovy Vary area – the parent rocks were the autometamorphic and mountain granites of the Karlovy Vary massif. It is the most important area of occurrence of the highest quality kaolins for the production of porcelain and their potential substitutes – titanium kaolins. There are also kaolins for the ceramics industry, and to a lesser extent also kaolins for the paper industry. The most important deposits are Božičany, Jimlíkov, Mírová and the Ruprechtov deposit opened in 2005, where kaolins for the production of porcelain and fine ceramics are mined together with titanium and ceramic kaolins. Kaolin for the paper industry is mined at the Otovice-Katzenholz deposit.
- Kadaň are – kaolins originated from granulite gneiss of the Ore Mountains crystalline complex. Kaolin can be used for the paper or ceramic industries. In 2003, the deposit Kralupy near Chomutov-Merkur (paper kaolin) was exhausted, other deposits were exhausted even earlier (e.g. Kadaň, Prahly). Since 2003, kaolin has been used for the paper industry in the large Rokle deposit, where overlying bentonite has also been mined for a long time.
- Podbořany are – the parent rock is the arkose sandstone of the Líně Formation of Central Bohemian Permocarbon. All the above-mentioned types of kaolins occur here. However, some kaolins evaluated as kaolins for the production of porcelain and fine ceramics are of lower quality (rather they should be ceramic to feldspar) and are used to a very limited extent as additives for the Karlovy Vary kaolins in the production of porcelain due to their rheological properties. The most important deposit is the large mined kaolin deposit for the production of porcelain and fine ceramics Krásný Dvůr-Podbořany.
- Pilsen area – the parent rock of kaolins are the carbonic arkoses of the Pilsen basin. Kaolins from this area are mainly usable as paper (the largest reserves of the highest quality raw material) and ceramic kaolins, slightly as feldspar kaolins and kaolins for the production of porcelain and fine ceramics. In 2005, in connection with the revaluation of reserves, most of the paper kaolins were transferred to the ceramic category. The most important large mined deposits of paper and ceramic kaolins are Horní Bříza, Kaznějov-jih and Lomnička-Kaznějov north and Chlumčany-Dnešice south of Pilsen.
- Znojmo area – kaolins originated mainly from the granitoids of the Dyje massif, and to a lesser extent from the Bíteš orthorhombic of the Dyje dome of the Moravicum. Kaolins are evaluated here mainly as feldspar and to a lesser extent paper kaolins. A small deposit of paper kaolin Únanov-sever was exhausted in 2007.
- Cheb Basin – kaolins were formed by kaolinisation of granites of the Smrčina massif. Only one deposit of Plesná-Velký Luh (ceramic and paper kaolins) is evaluated here, which has been used since 2018.
- Třeboň Basin – a small area where kaolins originated from granites and biotite paragneisses of the Moldanubian. Only ceramic kaolins on two small deposits are evaluated here:

Kolence and Klikov. Raw material is not mined, nor is its mining expected in the future due to its low quality.

- Vidnava – kaolins originated from granites of the Žulová massif. The raw material of the only one and no longer mined Vidnava deposit is alternatively evaluated as paper and ceramic kaolin, but for reasons of the best use of the raw material, it is registered among the clays for the production of refractory grogs.
- Other smaller occurrences of kaolins are either exhausted (Lažánky) or they were not yet explored (Žluticko, Toužimsko, Javornicko).

Czech kaolin deposits are also important from a global point of view, the most important being the Pilsen and Karlovy Vary areas, as well as the areas around Podbořany and Kadaň. All kaolin deposits in the Czech Republic are currently surface mined.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

Major deposit areas

*(Names of areas with exploited deposits are in **bold**)*

1 **Karlovy Vary Region**	4 **Plzeň Region**	7 Třeboň Basin
2 **Kadaň Region**	5 Znojmo Region	8 Vidnava
3 **Podbořany Region**	6 Cheb Basin	

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	71	71	77	77	77
exploited	15	15	18	18	18
Total mineral *reserves, kt	1,171,402	1,174,798	1,147,845	1,148,248	1,162,974
economic explored reserves	217,351	247,926	244,432	240,196	247,199
economic prospected reserves	499,514	484,216	461,095	465,952	481,923
potentially economic reserves	454,537	442,656	442,318	442,100	433,852
exploitable (recoverable) reserves	92,037	100,630	106,311	104,278	101,371
Mine production, kt [a)]	3,669	3,622	3,446	3,069	3,454
Beneficiated (water-washed) kaolin production, kt	676	653	629	626	645

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

[a)] *Raw kaolin, total production of all technological grades*

Approved prognostic resources P_1, P_2, P_3

Year	2017	2018	2019	2020	2021
P_1, kt	17 197*	17 197 *	17 197 *	17 197 *	17 197 *
P_2	–	–	–	–	–
P_3	–	–	–	–	–

*Note: * Kaolin for ceramics manufacturing*

The data of kaolin for production of porcelain and fine ceramics and kaolin used as fillers in paper industry have been stated separately due to great varieties of end use and prices of the individual kaolin types:

Number of deposits; reserves; mine production

Kaolin for production of porcelain and fine ceramics	2017	2018	2019	2020	2021
Deposits – total number	33	33	34	34	34
exploited	8	8	8	8	8
Total mineral *reserves, kt	245,209	244,864	244,590	244,294	244,044
economic explored reserves	48,094	47,749	47,483	47,187	46,937
economic prospected reserves	107,617	107,617	107,617	107,617	107,617
potentially economic reserves	89,498	89,498	89,490	89,490	89,490
exploitable (recoverable) reserves	16,086	15,773	23,245	23,079	15,270
Mine production, kt [a)]	304	313	239	266	226

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

a) Exploited deposits: Božičany-Osmosa-jih, Jimlíkov, Krásný Dvůr-Podbořany, Mírová, Podlesí 2, Podlesí-Čapí hnízdo, Ruprechtov

Number of deposits; reserves; mine production

Kaolin for paper industry	2017	2018	2019	2020	2021
Deposits – total number	26	31	31	31	31
exploited	7	8	9	9	9
Total mineral *reserves, kt	287,352	286,2980	285,410	283,549	277,701
economic explored reserves	49,765	60,253	58,732	56,904	57,886
economic prospected reserves	179,190	172,165	172,154	172,131	167,801
potentially economic reserves	58,397	54,563	54,524	54,514	52,014
exploitable (recoverable) reserves	30,878	32,541	31,324	30,441	31,260
Mine production, kt [a)]	1,420	1,362	1,256	1,234	1,322

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

a) Exploited deposits: Horní Bříza-Trnová, Chlumčany-Dnešice, Kaznějov-jih, Lomnička-Kaznějov, Otovice-Katzenholz, Rokle

5. Foreign trade

2507 – Kaolin and other kaolinic clays, whether or not calcined

		2017	2018	2019	2020	2021
Import	t	26,670	36,868	38,914	43,231	37,553
Export	t	557,456	561,503	537,827	471,566	505,634

2507 – Kaolin and other kaolinic clays, whether or not calcined

		2017	2018	2019	2020	2021
Average import prices	CZK/t	4,246	3,211	3,557	3,511	4,249
Average export prices	CZK/t	2,806	2,683	2,945	3,134	3,146

25070020 – Kaolin

		2017	2018	2019	2020	2021
Import	t	19,720	16,766	17,818	20,582	21,586
Export	t	557,456	561,049	537,578	471,370	505,461

25070020 – Kaolin

		2017	2018	2019	2020	2021
Average import prices	CZK/t	4,602	4,991	3,557	4,135	4,258
Average export prices	CZK/t	2,802	2,678	2,942	3,130	3,142

25070080 – Kaolinic clay (other than kaolin)

		2017	2018	2019	2020	2021
Import	t	6,959	20,101	21,097	22,650	15,967
Export	t	286	454	249	197	173

25070080 – Kaolinic clay (other than kaolin)

		2017	2018	2019	2020	2021
Average import prices	CZK/t	3,236	1,725	2,571	2,944	4,236
Average export prices	CZK/t	9,110	9,558	9,598	12,667	13,446

6. Prices of domestic market

Average prices of traded kaolin on the domestic market

In 2021, production prices of kaolins were in the following ranges:

Kaolin for ceramics manufacturing	CZK/t	2,040–3,100
Kaolin for paper industry	CZK/t	2,250–4,200
Kaolin other	CZK/t	3,000–5,600

7. Mining companies in the Czech Republic as of December 31, 2021

Kaolin for manufacture of porcelain and fine ceramics
Kaolin Hlubany, a.s.
Sedlecký kaolin a.s., Božičany
KSB s.r.o., Božičany

Kaolin for ceramics manufacturing
LB MINERALS, s.r.o., Horní Bříza
Sedlecký kaolin a.s., Božičany
KSB s.r.o., Božičany

Kaolin for paper industry
LB MINERALS, s.r.o., Horní Bříza
KERAMOST, a.s., Most
Sedlecký kaolin a.s., Božičany

Titanium-bearing kaolin
Sedlecký kaolin a.s., Božičany

Feldspar-bearing kaolin
In 2021 there were no companies mining feldspar-bearing kaolin on the territory of the Czech Republic

8. World production and world market prices

World mine production

World kaolin production in recent years was as follows:

	2017	2018	2019	2020	2021^e
World mine production (according to MCS), kt	37,000	42,200	44,300	46,400	45,000
World mine production (according to WBD), kt	45,199	45,410	44,213	42,856	N

e – preliminary values

Main producers according to MCS

2021^e		
Country	**kt**	**%**
India	7,600	17.3
China	6,400	14.5
Uzbekistan	5,500	12.5
USA	4,100	9.3
Czech Republic	3,100	7.0
Iran	1,800	4.1
Ukraine	1,600	3.6
Brazil	1,200	2.7
Turkey	1,200	2.7
Germany	800	1.8
Spain	450	1.0
Mexico	120	0.3
World	**44,000**	**100.0**

e – preliminary values

Prices of traded commodities

Commodity/year		2017	2018	2019	2020	2021
Kaolin, average US market price, ex works, according to MCS	USD/st	158	160	162	160	160
Kaolin Czech, average export price into Germany (CZSO)	EUR/t	85.28	90.37	96.96	99.06	128.14

Limestone and cement raw materials

1. Characteristics and use

Limestones as minerals are sedimentary (limestones in the narrow sense) and metamorphic (crystalline limestones or marbles) rocks formed by $CaCO_3$ (calcite or aragonite). Limestones were formed by chemical, biogenic and mechanical processes or combinations thereof. Dolomite and other components (silicate, phosphatic, etc.) form primary and secondary admixtures. Depending on their origin, limestones show different physical characteristics, structure, hardness, colour, weight and porosity, from low consolidated marls through chalk to compact limestones. The colour depends on the type of admixture (pyrite and organic matter – black, without admixture – light to white). Thermal and pressure transformation of limestones created crystalline limestones (calcitic marbles). Limestones are present in virtually all sedimentary geological formations and their metamorphic equivalents worldwide.

This raw material group also includes cement-corrective sialitic raw materials, e.g. shales, clays, loesses, loams, sands, etc., which correct the contents of SiO_2, Al_2O_3 and Fe_2O_3 in the clinker firing mixture and thus make it possible to adjust the chemical composition of the basic raw material. Most of them are rocks occurring directly on deposits of cement limestones or separately in the vicinity.

Reserves

They are extensive worldwide.

Uses

Limestones are used in the production of building materials (lime, cement, mortar, crushed stone, dimension and crushed stone, etc.), in metallurgy, in the chemical and food industries, newly in the desulphurisation of thermal power plants, in agriculture and in other fields (glass and ceramics industries, etc.). Cement corrective sialitic raw materials are used in the production of cement.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

According to their usability, limestones in the Czech Republic are divided into:

- High-percentage – with at least 96% of carbonate component (of which max. 2% $MgCO_3$). They are mainly used in the chemical, glass, food, rubber and ceramic industries, in metallurgy, for desulphurisation and for the production of lime of the highest quality (non-hydraulic lime).
- Others – with a carbonate content of at least 80%, used primarily for cement production, lime production, desulphurisation, etc. In the Czech Republic until 1997, dolomites and dolomitic limestones were included in this group.
- Clay – with $CaCO_3$ content around 70% and higher contents of SiO_2 and Al_2O_3. They are used for the production of cement and various types of lime.

- Carbonates for agricultural purposes – with a carbonate content of at least 70–75%. They are used in the treatment of agricultural and forest lands.

The above limestones are suitable as dimension and crushed stone (see next chapters).

Deposits and the main sources of limestones in the Czech Republic are concentrated in the following main areas:

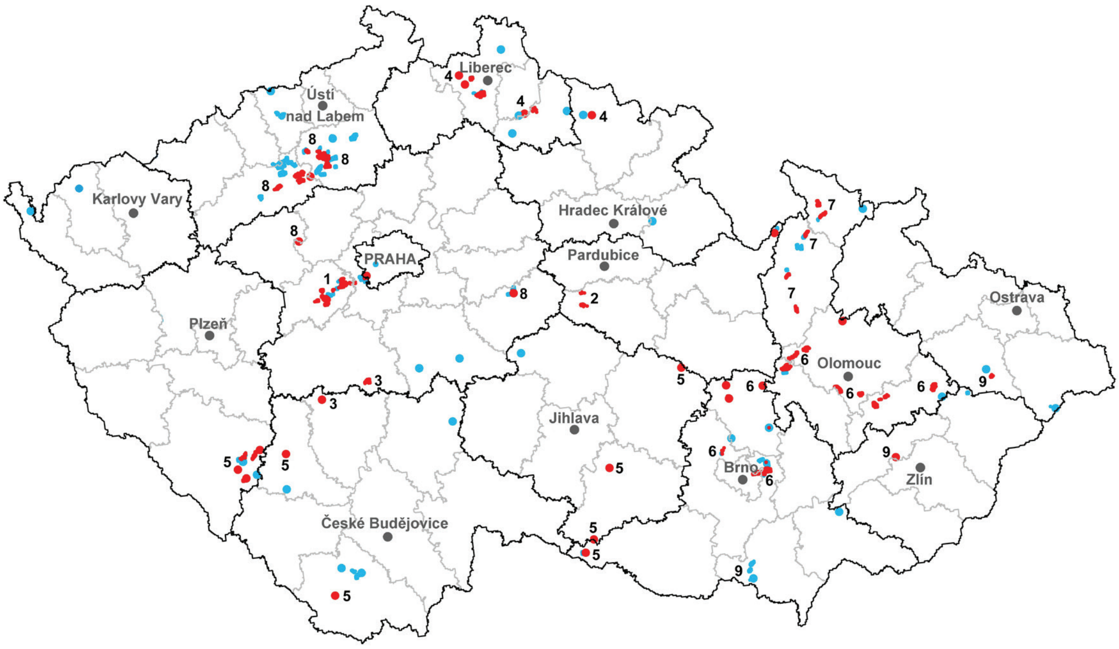
- Devonian rocks of the Barrandian – the most important and largest deposit area in the Czech part of the Czech Republic. Almost all types of raw materials are present, especially high-percentage limestones and other limestones, but also limestones for agricultural purposes and cement and correction raw materials. Deposits bound to sediments, mainly of Lower Devonian age, are usually formed by several lithological species. The purest of them are Upper Koněprusy limestones (average $CaCO_3$ contents approx. 98%). However, a significant part of the reserves and projected sources are linked to conflicts of interest with nature protection in the Bohemian Karst Protected Landscape Area. The most important used deposits are Koněprusy (high-percentage limestones), Kozolupy-Čeřinka (high-percentage and other limestones), Kosoř-Hvížďalka (other limestones), Loděnice (other limestones), Radotín-Špička (other limestones), Tetín (high-percentage limestones and others).
- Paleozoic of Železné Hory – a small area, but significant in terms of deposits. The raw material consists of crystalline Podolí limestones (high-percentage, 95% $CaCO_3$) and less pure darker crystalline limestones (other limestones, 90% $CaCO_3$). Prachovice deposit (high-percentage + others) is the only mined and decisive deposit.
- Central Bohemian Pluton islet zone – small isolated areas often with relatively pure, metamorphic limestones (mostly high-percentage and other limestones). The most important is the mined Skoupý deposit (high-percentage limestones).
- Krkonoše-Jizera crystalline complex – deposits of medium and smaller dimensions usually form lenses, deposited in phyllite and mica schist rocks. Limestones are crystalline, often with variable $MgCO_3$ contents (dolomitic limestones to calcareous dolomites – see chapter Dolomite) and SiO_2 (mainly other and agricultural limestones). Apart from the Lánov dolomite deposit, the only deposit used is Černý Důl (other limestones).
- Moldanubicum – deposits of smaller dimensions are represented by crystalline limestones, forming streaks or lenses in metamorphic rocks. Dolomitic limestones to dolomites commonly occur here together with limestones. Most deposits are evaluated as limestones for agricultural purposes and other limestones. Most deposits and reserves are concentrated in the Šumava Mts. Moldanubicum with the important used deposit Velké Hydčice-Hejná (other limestones).
- Moravian Devonian – the most important and very large deposit area of Moravia with deposits of various sizes. The main raw material in most deposits is the Vilémovice limestone (high-percentage; 96–97% $CaCO_3$). Furthermore, Křtice, Hády and Lažánky limestones (other limestones) are represented, evaluated mostly as cement raw material. The largest and most important deposits are concentrated in the sub-areas of the Moravian Karst with a large mined deposit Mokrá u Brna (high-percentage and other limestones and cement and correction raw materials) and the Hranice Devonian with a large mined deposit Hranice-Černotín (other limestones and cement and correction raw materials). Other, mostly unused deposits are found in the Konice-Mladeč Devonian, Čelechovice-Přerov Devonian and in the Devonian of the Boskovice Graben.
- The Silesian Bock (Branná group), Zábřeh group and Orlice-Kladsko crystalline complex –

smaller deposits of crystalline limestones, which form stripes in metamorphic rocks. They are often very pure (high-percentage limestones with up to 98% $CaCO_3$, less other limestones) and in the northern part of the territory also usable for stonemasonry. The most important mined deposits are Horní and Dolní Lipová (high-percentage and other limestones) in the Silesian Block and Vitošov (high-percentage limestones), which lie on the border of the Desná dome and the Zábřeh crystalline complex.

- Czech Cretaceous Basin (Ohře and Kolín area) – large to medium deposits. The raw materials are clayey limestones and marlstones with $CaCO_3$ contents between 80–60% (the most important area of clayey limestones). The used Úpohlavy-Chotěšov deposit (clayey limestones) is of key importance.
- The outer klippen zone of the Western Carpathians – limestones are formed by tectonically isolated blocks in the surrounding rocks (so called ridges). The raw materials are Štramberk limestones on the NE and Ernstbrunn limestones on the SW. They are very pure with average $CaCO_3$ contents of 95–98%, $MgCO_3$ around 1% (high-percentage limestones). The most important deposit is the Štramberk deposit (high-percentage and other limestones), which has since 2005 been the only mined deposit after mining was terminated at the Mikulov deposit.

Other areas of occurrence of carbonate rocks, such as the Krušné hory crystalline complex, the Nízký Jeseník Mts. culm, the Moravicum, the Tertiary of South and Central Moravia, etc., are mostly of only local significance. Deposits of limestones, cement raw materials and dolomites are surface mined in the Czech Republic.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

Major deposit areas

(Names of areas with exploited deposits are in ***bold****)*

1 **Devonian of the Barrandian**

2 **Paleozoic of the Železné hory Mts.**

3 **Central Bohemian Islet Zone**

4 **Krkonoše Mts.-Jizerské hory Mts. Crystalline Complex**

5 **South-Bohemian and Moravian Moldanubicum**

6 **Moravian Devonian**

7 **Silesicum (Branná Group), Orlické hory Mts.-Kladsko Crystalline Complex and Zábřeh Group**

8 **Bohemian Cretaceous Basin**

9 **Outer Klippen Belt of the Western Carpathians**

4. Basic statistical data of the Czech Republic as of December 31

Limestones – total number
Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	85	85	85	85	85
exploited	22	22	22	22	22
Total mineral *reserves, kt	4,728,765	4,724,605	4,724,605	4,712,955	4,178,073
economic explored reserves	2,024,489	2,020,399	2,020,399	2,009,011	1,761,116
economic prospected reserves	1,814,997	1,819,749	1,819,749	1,819,539	1,658,910
potentially economic reserves	889,279	884,457	884,457	884,405	758,047
exploitable (recoverable) reserves	932,830	1,609,852	1,131,050	1,257,354	1,196,691
Mine production, kt	10,787	11,727	11,357	11,296	11,007

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Limestones – total number
Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	82,489	82,489	82,489	82,489	82,489
P_2,	kt	350,957	350,957	350,957	350,957	350,957
P_3		–	–	–	–	–

Owing to the importance and considerable differences in technological use and prices, high-percentage limestones, corrective additives for cement production and other limestones are monitored separately.

High-percentage limestones containing 96 % or more of $CaCO_3$
Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	27	27	27	27	28
exploited	10	10	10	10	8
Total mineral *reserves, kt	1,292,797	1,287,127	1,288,592	1,284,292	1,275,664
economic explored reserves	689,757	684,084	685,552	681,209	672,717
economic prospected reserves	417,911	417,911	417,911	417,911	417,775
potentially economic reserves	185,129	185,129	185,129	185,172	185,172
exploitable (recoverable) reserves	621,932	506,916	497,389	529,9943	514,572
Mine production, kt	4,661	5,311	4,709	4,186	4,450

* See ***NOTE*** in the chapter ***Introduction*** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter ***Mineral reserve and resource classification in the Czech Republic*** of this yearbook

High-percentage limestones containing 96 % or more of $CaCO_3$
Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	5,400	5,400	5,400	5,400	5,400
P_2,	kt	26,345	26,345	26,345	26,345	26,345
P_3		–	–	–	–	–

Other limestones
Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	48	48	48	48	49
exploited	17	17	17	17	17
Total mineral *reserves, kt	2,308,294	2,311,489	2,311,976	2,305,870	2,303,207
economic explored reserves	964,765	968,030	968,552	962,716	963,761
economic prospected reserves	807,152	811,904	811,694	811,694	807,986
potentially economic reserves	536 377	531,555	531,460	531,460	531,460
exploitable (recoverable) reserves	666,927	577,988	593,759	568,906	644,359
Mine production, kt	4,833	4,824	5,601	5,523	5,451

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Other limestones
Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	71,267	71,267	71,267	71,267	71,267
P_2		–	–	–	–	–
P_3		–	–	–	–	–

Corrective additives for cement production
Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	13	13	13	13	13
exploited	2	2	2	2	2
Total mineral *reserves, kt	524,071	523,420	522,971	522,419	521,882
economic explored reserves	240,928	240,277	239,828	239,276	238,739
economic prospected reserves	156,785	156,785	156,785	156,785	156,785
potentially economic reserves	126,358	126,358	126,358	126,358	126,358
exploitable (recoverable) reserves	152,582	151,956	151,506	150,955	150,328
Mine production, kt	388	650	449	551	473

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Corrective additives for cement production
Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	84,493	84,493	84,493	84,493	84,493
P_2		–	–	–	–	–
P_3		–	–	–	–	–

In many limestone deposits, high-percentage limestones and other limestones are extracted together. Five out of fourteen corrective additives for cement production deposits make part of other limestones deposits.

5. Foreign trade

2521 – Limestone flux; limestone and other calcareous stone, of kind used for the manufacture of lime or cement

		2017	2018	2019	2020	2021
Import	t	328,117	357,831	294,296	343,891	421,109
Export	t	219,222	239,339	225,111	166,275	177,504

2521 – Limestone flux; limestone and other calcareous stone, of kind used for the manufacture of lime or cement

		2017	2018	2019	2020	2021
Average import prices	CZK/t	201	198	166	192	214
Average export prices	CZK/t	524	446	473	506	522

2522 – Quicklime, slaked lime and hydraulic lime

		2017	2018	2019	2020	2021
Import	t	59,437	81,256	91,140	78,831	102,793
Export	t	247,694	298,530	235,827	214,435	173,518

2522 – Quicklime, slaked lime and hydraulic lime

		2017	2018	2019	2020	2021
Average import prices	CZK/t	1,831	1,722	1,711	1,737	2,300
Average export prices	CZK/t	2,022	1,986	2,096	2,220	2,140

2523 – Portland cement, aluminous cement, slag cement, supersulphate cement and similar hydraulic cements, whether or not coloured or in the form of clinkers

		2017	2018	2019	2020	2021
Import	t	625,363	640,371	583,569	617,179	688,642
Export	t	588,589	749,334	785,000	568,895	621,962

2523 – Portland cement, aluminous cement, slag cement, supersulphate cement and similar hydraulic cements, whether or not coloured or in the form of clinkers

		2017	2018	2019	2020	2021
Average import prices	CZK/t	1,673	1,687	1,766	1,921	1,965
Average export prices	CZK/t	1,461	1,522	1,621	1,832	1,789

6. Prices of domestic market

Average prices of traded commodities on the domestic market

Product specification	2017	2018	2019	2020	2021
Cement CEM I, 42,5 R, on pallets, CZK/t	2,640	2,640	2,840	2,840	2,920
Cement CEM I, 42,5 R, on pallets, covered with foil, CZK/t	2,700	2,700	2,900	2,900	3,000
Cement CEM III A, 32,5 R, on pallets, CZK/t	2,300	2,300	2,600	2,660	2,720
Cement CEM III A, 32,5 R, on pallets, covered with foil, CZK/t	2,360	2,360	2,660	2,660	2,720
Dolomitic hydrated lime, bulk, CZK/t	3,000–3,790	3,000–3,790	5,840	4,100	4,500
Quicklime, ground, bulk, CZK/t	1,73–2,755	1,773–2,755	1,981–2,880	3,650–4,020	3,400–4,100
Limestone, ground, bulk, CZK/t	595–669	595–669	425–690	430–710	440–750
Limestone, crushed, CZK/t	189–408	189–408	253–450	190–550	200–550

7. Mining companies in the Czech Republic as of December 31, 2021

High-percentage limestones
Velkolom Čertovy schody, a.s.
Vápenka Vitošov s.r.o
LB Cemix, s.r.o.
Českomoravský cement, a.s.
LOMY MOŘINA spol. s r.o.
CEMEX Czech Republic, s.r.o
Vápenka Vitoul s.r.o.
Omya CZ s.r.o.
Agir spol. s r.o.

Other limestones
Českomoravský cement, a.s.
Cement Hranice, a.s.
CEMEX Czech Republic, s.r.o.
Omya CZ s.r.o.
HASIT Šumav. vápenice a omítkárny, s.r.o.
LB Cemix, s.r.o.
LOMY MOŘINA spol. s r.o.
Kalcit s.r.o., Brno
KLCT s.r.o.
Krkonošské vápenky Kunčice, a.s.
Velkolom Čertovy schody a.s.

Clayey limestones
Lafarge Cement, a.s.

Carbonates for agricultural use
PRACTIC 99, s.r.o.

Corrective additives for cement production
Českomoravský cement, a.s.
Cement Hranice, a.s.

8. World production and world market prices

World mine production

World limestone production is estimated at billions of tonnes. Its amount may be inferred from data on lime and cement manufacture. According to MCS data, world production of these two commodities in recent years was as follows:

Commodity/year	2017	2018	2019	2020	2021^e
World cement production, mill t	4 100	4 050	4 050	4 100	4 100
World lime production, mill t	350	413	424	432	420

e – preliminary values

The same table as the previous one, but including limestone; calculations are based on the relationship: 2 tonnes of limestone = 1 tonne of lime or 2 tonnes of cement (limestone production for construction purposes is not taken into account)

Commodity/year	2017	2018	2019	2020	2021[e]
World limestone production derived from the global cement production, mill t	4,050	4,050	4,100	4,200	4,400
World limestone production derived from the global lime production, mill t	826	848	864	852	860
World limestone production derived from the global lime production and cement production, mill t	4,876	4,898	4,964	5,052	5,260

e – preliminary values

Main producers according to MCS

2021[e]		
Cement		
Country	**kt**	**%**
China	2,500,000	56.8
India	330,000	7.5
Vietnam	100,000	2.3
USA	92,000	2.1
Indonesia	76,000	1.7
Turkey	66,000	1.5
Iran	65,000	1.5
Brazil	62,000	1.4
Russia	56,000	1.3
Japan	55,000	1.3
World	**4,400,000**	**100.0**

2021[e]		
Lime		
Country	**kt**	**%**
China	310,000	72.1
USA	17,000	4.0
India	16,000	3.7
Russia	11,000	2.6
Brazil	8,100	1.9
Japan	7,100	1.7
Germany	7,000	1.6
South Korea	5,200	1.2
Turkey	4,700	1.1
Italy	3,600	0.8
World	**430,000**	**100.0**

e – preliminary values

Prices of traded commodities – calcium carbonate

Commodity/year		2017	2018	2019	2020	2021
Cement, at plant USA (MCS)	USD/t	117.00	121.00	123.50	124.00 [e]	125[e]
Quick lime, at plant USA (MCS)	USD/t	120.8	125.2	128.3	132.1	140[e]
Hydrated lime, at plant USA (MCS)	USD/t	147,1	151,6	154,6	156,4	160[e]
Limestone, Slovakian, yearly average price of import into the Czech Republic (CZSO)	EUR/t	6.19	6.11	6.19	6.29	6.56

e – preliminary values

Silica minerals

1. Characteristics and use

Various types of rocks with a high content of SiO_2 are used as silica raw materials (usually at least 96% but over 99% for high quality glass and silicon production). These are various quartzites (sedimentary or metamorphic rocks, composed mainly of quartz and formed by silicification of sandstones or cementation of silica sands with silica binding agent), silicified sandstones, silicites, silica sands and boulders and vein and pegmatite quartz. Raw material quality requirements are set by standards. SiO_2 contents and heat resistance are monitored. The pollutants are high contents of especially Al_2O_3 and Fe_2O_3, or other oxides.

Reserves

They are extensive worldwide.

Uses

Silica materials are used to produce ferrosilicon for the steel industry, metallic silicon (semiconductors and solar photovoltaic panels), refractory building materials (dinas – bricks, mortars, ramming mass). They are also used for the production of porcelain and ceramics. Clear quartz, ultraviolet and optical glass (fibre) is produced from vein quartz, crystal and quartz boulders.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

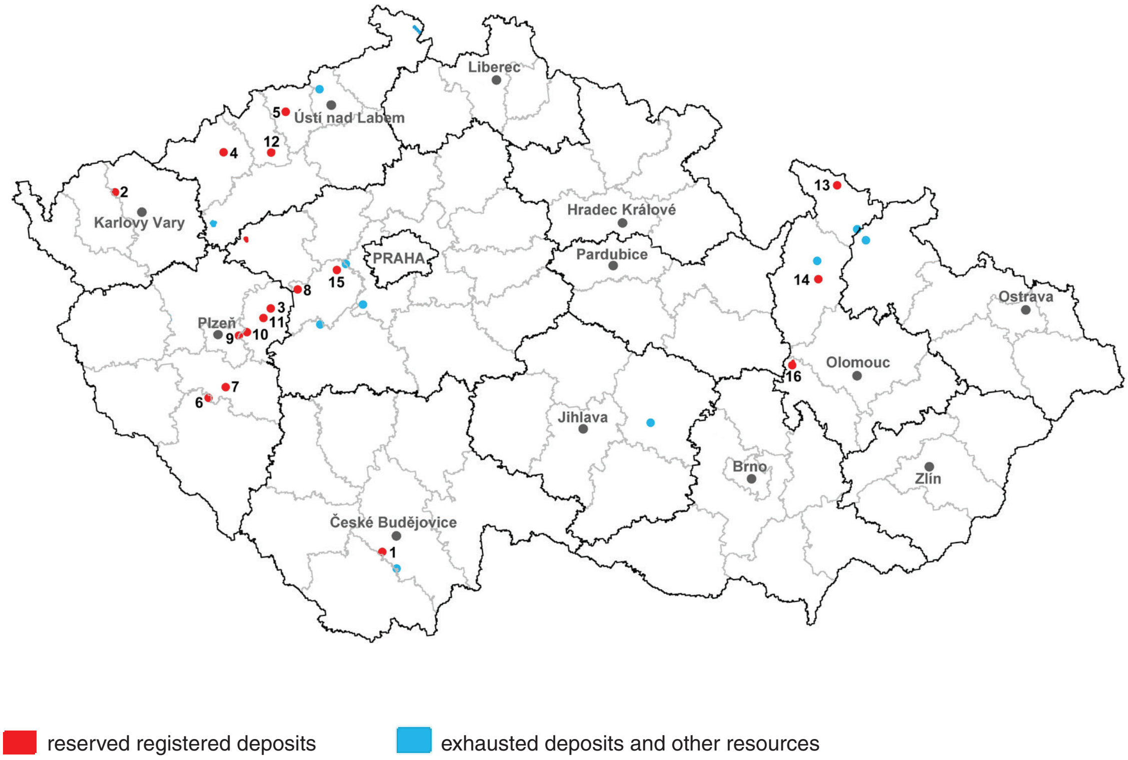
In the Czech Republic, silica materials are divided into silica materials and silica materials for special glasses. Deposits of silica materials are mainly related to the occurrences of "amorphous" Tertiary quartzite, Cretaceous "crystalline" quartzie and Ordovician quartzite, and to a lesser extent to deposits of vein quartz and silicites (lydites) of the Upper Proterozoic. At present, in the Czech Republic, with one exception, these raw materials are practically not mined and are mostly replaced by silica sands (entirely in the ceramic and glass industries), of which there is a sufficient amount on the market and which are also less variable and cheaper.

- Venous quartz deposits occur practically throughout the Czech Republic. The raw material can be used for the production of ferrosilicon, silicon and for ceramic and glass purposes. Accumulations of vein quartz are today unpromising due to low and fluctuating quality and they are gradually removed from the Register. Deposits and occurrences can be divided into several genetic groups:
- now insignificant deposits and occurrences of very pure quartz in pegmatites (Dolní Bory)
- silica veins of the rampart type (silicificated dislocation zones) in the Tachov region (Tachov-Světecká hora), in northern (Rumburk) and southern (Římov-Velešín) Bohemia and in the Jeseníky Mountains (Bílý Potok-Vrbno, Žárová)
- quartz veins bound to granitoid plutons (Žulová pluton: Velká Kraš, Karlovy Vary pluton: Černava-Tatrovice, Lusatian pluton: Rumburk, etc.)
- Deposits of "amorphous" quartz (quartz grains are bonded with very fine quartz bonding

agent) were formed by silicification of Tertiary and Upper Cretaceous deposits in Most area (Lužice u Mostu-Dobrčice, Stránce, Skršín) and Chomutov area (Chomutov-Horní Ves). In the Podbořany area (Skytaly, Vroutek) and Žlutice area they occur only in the form of relict boulders. Quartzite was a classic raw material for the production of dinas and the purest raw material can also be used for the production of metallic silicon. In the Podbořany area, quartzite was also used in ceramic production.

- Neoid silicification of Cretaceous sandstones created deposits of "crystalline" quartzites (isometric quartz grains) in Teplice area (Jeníkov-Lahošť, Střelná) and Most area (Bečov). Quartzites are usable mainly for metallurgical processing (mainly ferrosilicon), partly also for the production of dinas and metallic silicon.
- Of the Paleozoic quartzites, the Barrandian Ordovician quartzites (Kublov, Mníšek pod Brdy, Drahoňův Újezd-Bechlov, Sklená Huť, Železná) were of the greatest importance. They are usually rated as poorer in quality for the production of ferrosilicon and to a lesser extent dinas. Other larger accumulations of quartzites and quartz rocks are in the Devonian rocks of the Silesian Bock (Vikýřovice), etc. These quartzites are of low quality and are suitable after treatment for the production of lower quality dinas.
- In the future, perhaps the deposits of Upper Proterozoic silicites (cobblestones) could prove useable for the industries for the amount of their reserves and their quality, especially in the Rokycany area (Litohlavy, Kyšice-Pohodnice) and Přeštice area (Kaliště, Kbelnice). According to tests, the raw material could be suitable for the production of silicon alloys and perhaps even partially for the production of dinas.
- Once, cobble quartz from the extraction of sand and gravel in the Elbe, Dyje, Cheb region, etc was also considered a possible raw material for the production of silicon and special types of glass. At present, the 16–50 mm fraction is used in this way at the Vrábče-Boršov deposit in the Budějovice basin, which consists practically only of quartz boulders (other rocks, limonitised boulders and other impurities are picked out by hand). Gravel is exported to Germany (around 20 kt per year) as a silica material for the production of ferrosilicon.
- Only milky white vein quartz is suitable after treatment as a silica material for special glasses. In the Příbram area (Krašovice) it is bound to the Central Bohemian pluton (zone of metamorphic islets) and in the Prostějov area (Dětkovice) to hydrothermal veins, which have undergone metamorphosis together with the surrounding rocks (phyllites).

3. Registered deposits and other resources of the Czech Republic



Quartz – quartzites

1 **Vrábče-Boršov**	6 Kaliště	11 Sklená Huť
2 Černava-Tatrovice	7 Kbelnice	12 Stránce
3 Drahoňův Újezd-Bechlov	8 Kublov-Dlouhá Skála	13 Velká Kraš
4 Chomutov-Horní Ves	9 Kyšice-Pohodnice	14 Vikýřovice
5 Jeníkov-Lahošť	10 Litohlavy-Smrkový vrch	15 Železná

Quartz for special glass

16 Dětkovice	17 Krašovice

(Names of exploited deposits are in ***bold type****)*

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	16	16	17	15	15
exploited	1	1	1	1	1
Total mineral *reserves, kt	251,182	25 166	26,679	26,668	26,526
economic explored reserves	763	763	763	763	924
economic prospected reserves	20,230	20,214	21,727	21,716	21,416
potentially economic reserves	4,189	4,189	4,189	4,189	4,189
exploitable (recoverable) reserves	377	445	428	417	188
Mine production, kt	17	16	17	11	20

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	4,533	4,533	4,533	4,533	4,533
P_2		–	–	–	–	–
P_3		–	–	–	–	–

5. Foreign trade

2506 – Quartz (other than natural sands); quartzite, whether or not roughly trimmed or merely cut

		2017	2018	2019	2020	2021
Import	t	10,310	12,526	15,128	11,971	43,350
Export	t	85	64	8	1	69

2506 – Quartz (other than natural sands); quartzite, whether or not roughly trimmed or merely cut

		2017	2018	2019	2020	2021
Average import prices	CZK/t	2,467	2,185	2,210	2,223	689
Average export prices	CZK/t	20,889	4,891	1,166	68,571	63,611

720221 – Ferrosilicon

		2017	2018	2019	2020	2021
Import	t	23,883	31,943	25,397	23,659	26,843
Export	t	7,124	13,662	11,997	10,598	12,576

720221 – Ferrosilicon

		2017	2018	2019	2020	2021
Average import prices	CZK/t	31,189	33,411	26,785	25,930	38,498
Average export prices	CZK/t	26,221	29,911	23,458	21,849	34,262

6. Prices of domestic market

Prices of silica minerals are not open to public.

7. Mining companies in the Czech Republic as of December 31, 2021

Budějovické štěrkopísky, spol. s r.o., Vrábče

8. World production and world market prices

World mine production

World production of silicon in recent years:

	2017	2018	2019	2020	2021[e]
Silicon production (according to MCS), kt	6,580	7,400	8,410	8,120	8,500

e – preliminary values

Main producers according to MCS – Si metal and Si in ferrosilicon

Country	2021^e	
	kt	%
China	6,000	70.6
Russia	580	6.8
Brazil	390	4.6
Norway	350	4.1
USA	310	3.6
France	120	1.4
Iceland	110	1.3
Malaysia	80	0.9
Bhutan	70	0.8
Kazakhstan	67	0.8
World	**8,500**	**100.0**

e – preliminary values

Prices of traded commodities –

– **silicon** (USc/lb), US market, according to MCS

Commodity/year	2017	2018	2019	2020	2021
Silicon metal, metallurgical grade	117	134	106	97	140

– **ferrosilicon** (EUR/t), according to MCS

Komodita/rok	2017	2018	2019	2020	2021
Ferosilicon, 50% Si, price average, USc/lb (MCS)	94	104	102	103	110
Ferosilicon, 75% Si, price average, USc/lb (MCS)	87	108	89	87	140

CONSTRUCTION MINERALS

The term construction minerals is employed for all minerals used in the construction industry, such as transport, construction, water, industrial, residential and other buildings, the production of concrete, mortar and bituminous mixtures, bricks and blocks. Minerals for the production of building materials, especially carbonates, are classified industrial minerals in the Czech Republic.

The Czech Republic has extremely large geological reserves of construction minerals. The total verified sources of construction minerals in the Czech Republic are around 20 billion tonnes and a total of around 65 million tonnes are mined annually (in 2021 their mining reached 68.408 million tonnes), their share in the total extraction of raw materials is gradually increasing and currently is about 60%. In 2021 82,5% of the production of construction minerals comes from reserved deposits, which account 55.507 million tonnes. The decisive importance have crushed stone and sand and gravel, which together make up 97% of the volume (over 62 million tonnes) of all extracted construction minerals. The share of production from reserved deposits in crushed stone and sand and gravel together is 80% (in 2021 52.068 million tonnes). It is higher for crushed stone, where extraction from reserved deposits represents 90% of the total extraction of crushed stone. For sand and gravel, the production from reserved deposits accounts for only 57% of the total production.

In the Czech Republic, we divide construction minerals into the following basic groups:

– **Crushed stone**, which is used either untreated (quarry stone) or it mainly used to produce crushed aggregate, which is also its technical name
– **Sand and gravel**, which are technically called mined aggregates
– **Brick clays and related minerals**, suitable alone or in a mixture for brick production
– **Dimension stone**, stone for rough and noble stonemasonry

Brick clays and related minerals

1. Characteristics and use

Brick clay includes all types of raw materials suitable alone or in a mixture for brick production. The following types of rocks are most often used for this purpose: loess, loess and slope loams, clays and claystones, marls, slate wastes and others. The production material itself has two main components – plastic and opening material (grog), which are proportionally represented either directly in the raw material or the optimal ratio of both can be obtained by mixing them. The component (base) that predominates in the production mixture is essential; the additional component, which modifies the properties of the raw material, is corrective (depending on the nature, it has a plasticising or non-plasticising function), or ingredient. The pollutants in the brick clay are mainly carbonates, gypsum, siderite, organic substances, larger rock fragments, etc.

Reserves

They are extensive worldwide. Deposits of brick clay in the world are located practically everywhere and are not generally registered.

Uses

Brick production (bricks, brick blocks, roofing tiles, clay).

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

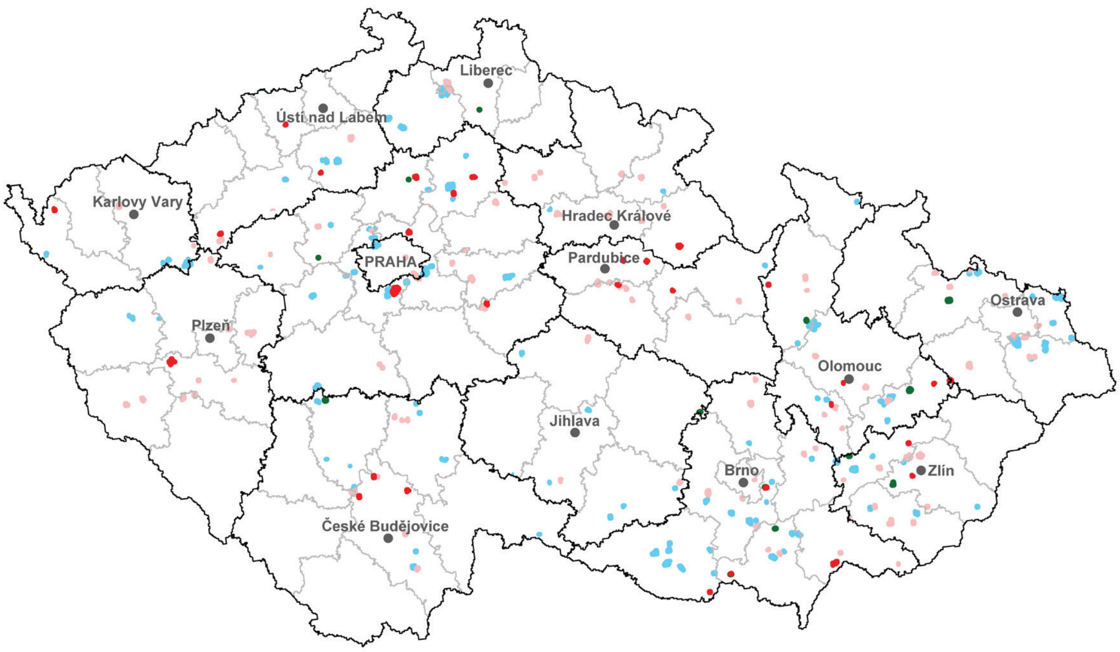
Among the brick clays in the Czech Republic, Quaternary loams of various genesis predominate as the basic component. The source of natural corrective raw materials are mostly deposits of pre-Quaternary age.

- Deposits of Quaternary raw materials (loess and loess loams, clays, sands and sandy-clay rock residues) are widespread throughout the country and are the most abundantly mined. The most important of them are tied to aeolian and deluvial-aeolian, or glacial (northern Bohemia and Silesia) sediments. In aeolian sediments, buried soil horizons, clasts and calcareous concretions are pollutants; the deluvial ones contain hard clasts. Aeolian raw materials are suitable (usually in a mixture) for the production of demanding thin-walled elements. Deluvial raw materials can be used as corrective components for more plastic soils or for the production of thick-walled masonry shards.
- Neogene pelites are a more widespread pre-Quaternary raw material of the limnic basins of Bohemia and the Vienna Basin. They are characterised by a sandy admixture and locally also by the increased presence of montmorillonite or clasts, in the area of the Vienna Basin and the Carpathian foredeep also by an increased content of soluble salts. They are one of the long-used raw materials. They are also suitable for the production of demanding thin-walled load-bearing and shaped products.
- Paleogene claystones (also calcareous) are used in eastern and southeastern Moravia. These are weathered parts of the flysch layers of the outer Western Carpathians nappes. Flowering

substances and sandstone benches are serious pollutants. The product range is limited to solid bricks or perforated products.

- Upper Cretaceous clays and claystones (often calcareous) are used as the basic raw material in the area of the Czech Cretaceous Basin and South Bohemian basins. Marls, marlstones and sand as a correction. The raw material is suitable for the production of even the most demanding perforated masonry and ceiling materials; in southern Bohemia due to the occurrence of limonitised sandstone for the production of undemanding masonry products.
- Permocarbon pelites and aleuropelites serve as a raw material in the areas of the Permocarbon basins and trenches of Bohemia and Moravia. The presence of sandstones in the formation and the complex structure of deposits are characteristic. They give the possibility of production of fired roofing and thin-walled products.
- Early Proterozoic and Old Paleozoic weathered shales and their residues are used in the vicinity of Prague, Pilsen, Rokycany, etc. The usual pollutants are solid clasts and pyrite. They are not suitable for the production of more demanding brick products.

3. Registered deposits and other resources of the Czech Republic



reserved deposits – exploited (16)
reserved deposits – unexploited (110)
non-reserved deposits – exploited (8)
non-reserved deposits – unexploited (118)

There are large numbers of brick mineral deposits registered in the Czech Republic and thus they are not listed in this overview. Their distribution over the Czech territory is rather uneven and consequently in some regions there is a shortage of these minerals (e.g. Českomoravská vrchovina Highlands covering most of the area of Vysočina Region with capital Jihlava).

4. Basic statistical data of the Czech Republic as of December 31

Reserved deposits: Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	130	130	129	129	126
exploited	17	17	15	15	16
Total mineral *reserves, ths m^3	530,342	529,033	527,679	526,197	525,687
economic explored reserves	197,863	196,673	194,738	193,821	193,458
economic prospected reserves	228,242	228,123	227,968	227,884	227,971
potentially economic reserves	104,237	104,237	104,973	104,492	104,258
exploitable reserves	58,039	57,541	56,505	59,553	65,882
Mine production in reserved deposits, ths m^3	678	825	694	560	595

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	ths m^3	25,691	25,691	25,691	25,691	25,691
P_2,	ths m^3	245,459	224,159	224,159	224,159	224,159
P_3		–	–	–	–	–

Non-reserved deposits: Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	125	125	125	123	126
exploited	6	6	6	7	8
Total mineral *reserves, ths m^3	694,119	693,821	693,532	692,192	692,731
economic explored reserves	63,622	63,622	63,622	63,609	65,612
economic prospected reserves	523,644	523,346	523,057	521,313	519,845
potentially economic reserves	106,853	106,853	106,853	107,270	107,274
exploitable reserves	10,919	10,621	10,514	10,697	10,654
Mine production in non-reserved deposits, ths m^3 [a)]	251	298	301	404	411

* *See* *NOTE* *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

[a)] *estimate*

5. Foreign trade

690410 – Building bricks

		2017	2018	2019	2020	2021
Import	ths pcs	14,283	19,080	17,304	14,568	22,592
Export	ths pcs	14,134	17,725	15,399	15,606	18,637

690410 – Building bricks

		2017	2018	2019	2020	2021
Average import prices	CZK/piece	14.4	18.3	22.0	21.4	22.2
Average export prices	CZK/piece	29.1	26.2	32.5	35.1	34.8

690510 – Roof tiles

		2017	2018	2019	2020	2021
Import	ths pcs	8.251	10.883	9.395	8.697	13.855
Export	ths pcs	10.582	11.572	9.608	9.979	10.924

690510 – Roof tiles

		2017	2018	2019	2020	2021
Average import prices	CZK/piece	19.0	18.0	18.7	21.2	18.7
Average export prices	CZK/piece	18.0	17.0	18.4	18.8	20.6

6. Prices of domestic market

Domestic prices of brick clay and brick products

Product specification	2017	2018	2019	2020	2021
Brick clay; CZK/t	95	95	95	95	95
Full brick; CZK/piece	3.9–5.8	3.9–5.9	5.0–9.4	6.5–10	8.9
Honeycomb brick; CZK/piece	10.5–15	10.8	10.5–13.0	14	17
Facing bricks; CZK/piece	10.5–30	20–54	20–55	22–50	23–53
Brick blocks Porotherm; CZK/piece	24–110	62–180	62–180	71–210	80–250
Clay (ground clay bricks for tennis courts); CZK/t	1,450	1,550–2,550	1,550–3,190	1,550–2,950	1,750–2,950
Roof tiles; CZK/t	15.5–48	25.8–51	25–51	29–55	28–62
Ventilating, boundary tile; CZK/t	86–205	71–230	68–246	269	275
Classical shingle tile; CZK/t	12–60	13–32	9–32	14–35	17–43

7. Mining companies in the Czech Republic as of December 31, 2021

Brick clays and related minerals – reserved deposits
Wienerberger Cihlářský průmysl, a.s., Č. Budějovice
Cihelna Kinský s.r.o., Kostelec n.Orl.
HELUZ cihlářský průmysl v.o.s., Dolní Bukovsko
Cihelna Hodonín, s.r.o.
Cihelna Vysoké Mýto s.r.o.
LB MINERALS, s.r.o., Horní Bříza

Brick clays and related minerals – non-reserved deposits
HELUZ cihlářský průmysl v.o.s., Dolní Bukovsko
Wienerberger Cihlářský průmysl, a.s., Č. Budějovice
Ing. Jiří Hercl, cihelna Bratronice, Kyšice
Ing. Ladislav Konečný-Cihelna Šitbořice

8. World production and world market prices

Global mining of brick clays is not statistically recorded and many states do not monitor it at all.

Brick clays are not subject to global trade.

Crushed stone

1. Characteristics and use

The term building stone includes all solid igneous, sedimentary and metamorphic rocks, if their technological properties correspond to the conditions determined according to the purpose of their use. It must have certain physical-mechanical properties which result from its genesis, mineralogical composition, structure, texture, secondary transformations and other characteristics. The rocks are used in the mined state (quarry stone) or mainly in the dressed state (aggregate). The pollutants are faulty, crushed, weathered or altered zones, locations of technologically unsuitable rocks, higher contents of sulphur compounds and amorphous SiO_2 and others.

Reserves

They are extensive and inexhaustible worldwide.

Uses

Building industry.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

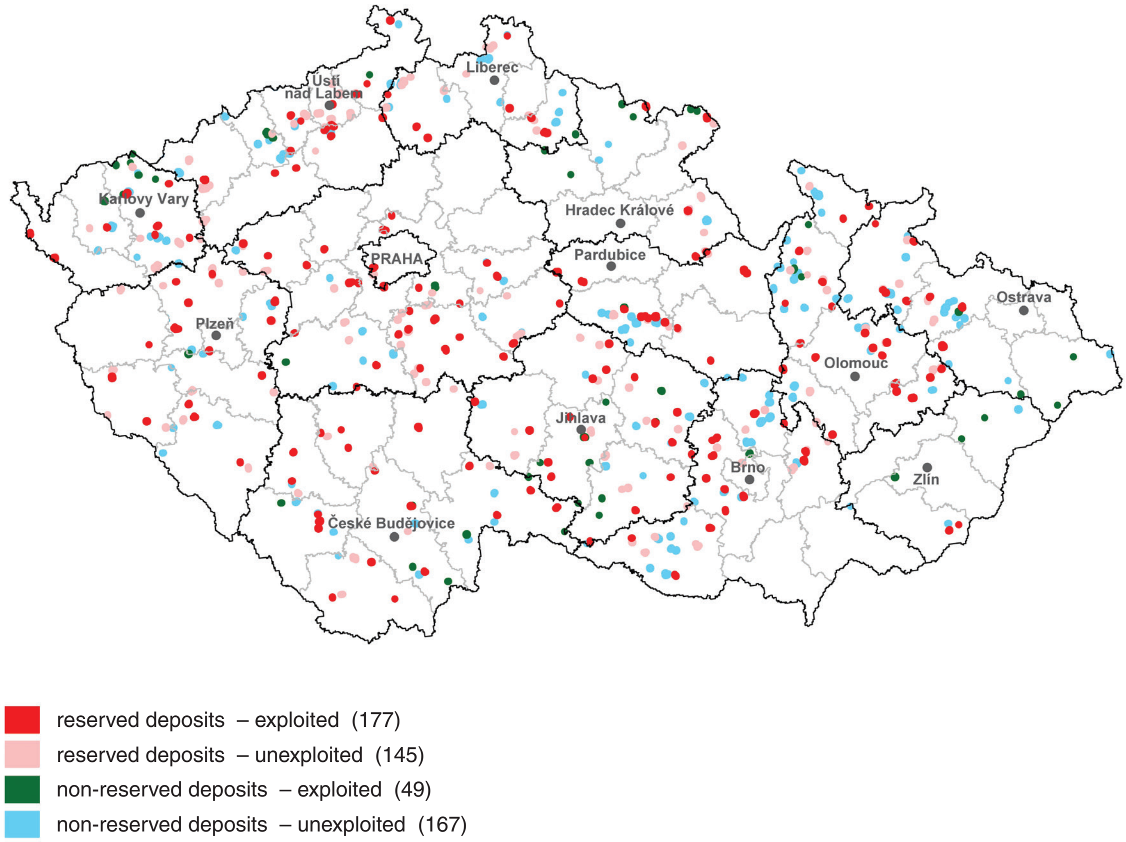
Industrially usable deposits of building stone are widespread throughout the Bohemian Massif, significantly less in its basin areas. In the Western Carpathians, deposits are present only rarely.

- Currently, the most important positions are regionally metamorphosed deposits – they are generally crystalline shales, which are bound exclusively to crystalline complexes of the Bohemian Massif – Moldanubicum, Moravicum, Silesicum, crystalline complex of the Slavkov Forest, West Sudeten, Kutná Hora and Domažlice crystalline complex, South Bohemian and Bory granulite massif, etc. In addition to technologically very suitable rocks (orthogneiss, granulites, amphibolites, serpentines, crystalline limestones, etc.), there are also less suitable rocks (micashists, paragneisses, quartzites). Deposits of contact metamorphosed rocks (hornstones, shales) at the contact of the Central Bohemian and Nasavrky plutons with Algonquian and Paleozoic sediments are of minor importance. Metamorphic (regional and contact) rocks account for about 30% of the total production of crushed stone in the Czech Republic.
- Sedimentary rocks are of constant importance, among which deposits of consolidated clastic sediments (siltstones, greywackes, sandstone, etc.) predominate. The foremost place is occupied by the Kulm greywackes of Nízký Jeseník and Drahanská vrchovina. They also occur in the Proterozoic Barrandian, the Moravian Devonian and the flysch zone of the Carpathians. The share of sedimentary rocks in the total production of crushed rocks in the Czech Republic has recently decreased slightly and currently clastic sedimentary rocks (mainly greywackes) make up around 24–25% of the total production.
- In the recent past, the main source of raw material for the production of crushed stone in the Czech Republic were deposits of flowing rocks. Deposits of paleovolcanics (effusive rocks

of pre-Tertiary age) occur practically only in the Barrandian (consolidated pyroclastics are also suitable here), in the Krkonoše Mts. piedmont basin and the Intra-Sudetic Basin. Sometimes they contain layers of pyroclastics or secondary metamorphosed rocks. Deposits of basic rocks – spilites, diabases, etc. are especially important. The deposits of basic (especially basaltic) rocks are also of the greatest importance within deposits of neovolcanics (effusive rocks of post-Cretaceous age). They are concentrated mainly in the České středohoří Mts. and the Doupov Mountains, less so in the neovolcanic area of the Czech Cretaceous Basin and the Nízký Jeseník Mts. and in the area around Železný Brod. Their share in the total production of crushed aggregate in the Czech Republic has been slightly decreasing in recent years and basic volcanics currently make up about 23–24%.

- Deep igneous deposits are also an important source of crushed stone (especially granite and quartz diorites). Various types of rocks (including vein accompaniment) with suitable technological parameters are mined in many places of the Central Bohemian pluton, the central Moldanubian pluton, the Železné Hory pluton (Nasavrky massif), the Brno massif and other plutonic bodies. Separate deposits of vein rocks are of little importance. Deep igneous rocks account for about 20% of the total production of crushed stone in the Czech Republic.
- Chemogenic and organogenic deposits are represented by carbonates (Barrandian older Paleozoic, Moravian-Silesian Devonian) and silicites (lydites in the Algonquian in the Pilsen area). They account for about 2% of the total production of crushed stone in the Czech Republic.
- A small amount of suitable clays from the overlying Cypris formation in the Sokolov Basin is used for the production of lightweight aggregate (LIAPOR).

3. Registered deposits and other resources of the Czech Republic



Because of the large number of crushed stone deposits in the Czech Republic, they are not listed.

4. Basic statistical data of the Czech Republic as of December 31

Reserved deposits: Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	321	321	319	320	322
exploited	178	180	176	175	177
Total mineral *reserves, ths m^3	2,427,689	2,439, 218	2,457,253	2,478, 611	2,491,395
economic explored reserves	1,179,031	1,118,023	1,173,441	1,183, 964	1,181,819
economic prospected reserves	1,103,824	1,172,439	1,133, 231	1,142,587	1,157,520
potentially economic reserves	144,827	148,756	150,581	152,060	152,056
exploitable reserves	713,100	744,315	693,865	703,856	739,016
Mine production in reserved deposits, ths m^3	12,776	14,140	14,057	14,247	14,765

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	ths m^3	3,040	3,040	3,040	3,040	3,040
P_2,	ths m^3	–	–	–	–	–
P_3		–	–	–	–	–

Non-reserved deposits: Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	223	221	222	215	216
exploited	46	45	47	48	49
Total mineral *reserves, ths m^3	1,026,215	1,029,172	1,030,196	1,030,658	1,090,666
economic explored reserves	39,428	39,380	40,544	40,480	41,801
economic prospected reserves	908,480	911,485	911,345	912,416	918,307
potentially economic reserves	78,307	78,307	78,307	77,762	130,558
exploitable reserves	48,720	47, 469	52,878	48,268	55,069
Mine production in non-reserved deposits, ths m^3 a)	1,251	1,151	1,449	1,465	1,741

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

a) estimate

5. Foreign trade

251710 – Pebbles, gravel, broken or crushed stone

		2017	2018	2019	2020	2021
Import	t	217,704	684,531	1,147,319	1,177,472	1,161,633
Export	t	482,285	551,516	723,318	355,755	504,742

251710 – Pebbles, gravel, broken or crushed stone

		2017	2018	2019	2020	2021
Average import prices	CZK/t	236	229	188	205	173
Average export prices	CZK/t	237	217	200	202	180

6. Prices of domestic market

Domestic prices of crushed stone – nationwide

Product specification	2017	2018	2019	2020	2021
crushed stone, spilite, fraction 4–8mm, CZK/t	298	308	334	369	405
crushed stone, amphibolite, fraction 4–8 mm, CZK/t	357	378	386	384	420
crushed stone, granite, fraction 4–8 mm, CZK/t	331	355	353	368	394
crushed stone, gneiss, fraction 4–8 mm, CZK/t	325	341	342	345	418
crushed stone, porphyry, fraction 4–8 mm, CZK/t	321	329	318	355	394
crushed stone, granodiorite, fraction 4–8 mm, CZK/t	330	351	349	376	401
crushed stone, greywacke, fraction 4–8 mm, CZK/t	327	343	376	343	407
crushed stone, basalt, fraction 4–8 mm, CZK/t	318	315	338	365	373
crushed stone, hornfels, fraction 4–8 mm, CZK/t	299	283	307	292	341
crushed stone, limestones, fraction 4–8 mm, CZK/t	297	333	329	375	377
crushed stone, spilite, fraction 8–16 mm, CZK/t	267	285	295	326	342
crushed stone, amphibolite, fraction 8–16 mm, CZK/t	270	298	301	307	343
crushed stone, granite, fraction 8–16 mm, CZK/t	258	266	282	288	318
crushed stone, gneiss, fraction 8–16 mm, CZK /t	264	270	287	276	335
crushed stone, porphyry, fraction 8-16 mm, CZK/t	262	273	264	295	296
crushed stone, granodiorites, fraction 8–16 mm, CZK /t	273	276	293	316	332
crushed stone, greywacke, fraction 8–16 mm, CZK /t	282	288	334	288	312
crushed stone, basalt, fraction 8–16 mm, CZK /t	282	283	310	316	323
crushed stone, hornfels, fraction 8–16 mm, CZK /t	264	268	282	268	300
crushed stone, limestones, fraction 8–16 mm, CZK /t	253	282	289	315	313

Average domestic prices of crushed stone in 2021 – subdivided by rocks and regions which the rocks are mined in

2021		Average prices of (listed) fractions (CZK/t)								
Rock-mineral	Size fraction / Region/average of fraction price	0-4 mm	0-32 mm	0-63 mm	4-8 mm	8-16 mm	32-63 mm	LK unsorted	In region	In all regions
opoka-sandstone	Central Bohemia	FN	FN	220	FN	FN	FN	150	185	
	Zlín	FN	295	290	470	FN	335	150	308	
	Average of fraction price	FN	295	145	470	FN	335	150		279
serpentine	Central Bohemia	150	159	165	291	241	204	200	200	
	Average of fraction price	140	159	165	291	241	204	200		200
limstone	Central Bohemia	202	190	194	364	294	260	255	251	
	Prague	240	240	240	420	340	300	FN	297	
	Olomouc	227	206	210	407	309	217	206	255	
	South Bohemia	175	253	263	314	FN	259	222	248	
	Hradec Králové	387	259	232	374	353	FN	189	299	
	Moravia and Silesia	180	195	205	382	270	210	200	235	
	Average of fraction price	235	224	224	377	313	249	214		262
basaltic rocks	Karlovy Vary	267	248	216	350	290	257	210	263	
	Hradec Králové	210	205	206	320	265	297	240	249	
	Central Bohemia	230	232	230	380	343	293	290	285	
	Plzeň	220	217	210	391	316	250	219	260	
	Pardubice	240	230	225	430	320	235	230	273	
	Prague	210	215	FN	380	320	315	325	294	
	Moravia and Silesia	195	FN	FN	291	349	FN	FN	278	
	Liberec	206	250	258	438	375	267	260	293	
	Ústí nad Labem	240	250	227	378	326	255	260	277	
	Average of fraction price	224	231	225	373	323	271	254		272
greywacke	South Bohemia	220	185	190	420	250	230	220	245	
	South Moravia	178	191	175	420	350	245	220	254	
	Olomouc	210	205	198	408	340	247	225	262	
	Moravia and Silesia	223	203	208	381	309	235	220	254	
	Average of fraction price	208	196	193	407	312	239	221		254
skarn	Central Bohemia	165	245	230	395	3340	280	240	699	
	Average of fraction price	150	200	210	290	280	220	220		224
gneiss	Plzeň	180	220	225	359	278	236	173	239	
	South Moravia	149	215	212	375	290	237	260	248	
	Vysočina	177	206	212	401	315	259	252	260	
	Pardubice	240	180	207	410	340	275	250	272	
	Central Bohemia	230	255	260	440	360	265	245	294	
	Olomouc	230	229	229	459	351	229	206	276	
	Hradec Králové	223	285	284	480	411	363	250	328	
	Average of fraction price	204	227	233	418	335	266	234		274
hornfels	Pardubice	FN	205	200	335	310	240	225	253	
	Central Bohemia	150	210	205	347	290	252	285	248	
	Average of fraction price	150	208	203	341	300	246	255		243
amphibolite	Plzeň	261	258	223	392	326	273	240	282	
	South Moravia	195	215	210	375	325	235	200	224	
	Olomouc	221	209	221	376	313	246	212	257	
	Central Bohemia	170	215	215	435	325	255	218	262	
	Hradec Králové	270	215	245	460	380	295	260	304	
	Vysočina	270	240	240	480	390	320	265	315	
	Average of fraction price	231	225	226	420	343	271	233		278
granitic rocks	South Moravia	210	236	213	375	315	240	209	257	
	Karlovy Vary	200	190	212	352	280	260	200	242	
	Pardubice	211	205	211	405	330	267	211	263	
	Hradec Králové	210	215	220	425	335	283	260	278	
	Central Bohemia	180	210	220	386	342	264	285	270	
	South Bohemia	213	243	235	419	318	260	215	272	
	Vysočina	206	205	203	396	308	255	220	256	
	Ústí nad Labem	185	235	200	FN	FN	FN	330	238	
	Average of fraction price	171	217	214	394	318	261	241		260
granulite	South Bohemia	185	255	255	415	322	272	218	275	
	Average of fraction price	185	255	255	415	322	272	218		275

Explanations:
FN: frction is not produced
LK: quarry stone
basaltic rocks: melaphyre+spilite+basalt+phonolite
granitic rocks: granodiorite+granite+syenite+diorite+porphyry
limestone: limestone+dolomite+marble
gneiss: orthogneiss+paragneiss

Average domestic prices of crushed stone in 2021 – subdivided by regions and rocks mined in them

	2021	Average prices of (listed) fractions (CZK/t)							
Region	Size fraction / Rock-mineral/price	0-4 mm	0-32 mm	0-63 mm	4-8 mm	8-16 mm	32-63 mm	LK unsorted	In region
Plzeň	gneiss	180	220	225	359	278	236	173	
	amphibolite	261	258	223	392	326	273	240	
	basaltic rocks	220	217	210	391	316	250	219	
	meta-greywacke	255	223	210	365	323	265	235	
	Average of fraction prices in the region	**229**	**230**	**217**	**377**	**311**	**256**	**217**	**262**
South Moravia	greywacke	178	191	175	420	350	245	220	
	gneiss	149	215	212	375	290	237	260	
	granitic rocks	210	236	213	375	315	240	209	
	amphibolite	195	215	210	375	325	235	200	
	Average of fraction prices in the region	**183**	**214**	**203**	**386**	**320**	**239**	**222**	**253**
Karlovy Vary	granitic rocks	200	190	212	352	280	260	200	
	basaltic rocks	267	248	216	350	290	257	210	
	trachyt	FN	190	215	FN	FN	210	FN	
	Average of fraction prices in the region	**234**	**209**	**214**	**351**	**285**	**242**	**205**	**249**
Moravia and Silesia	limestone	180	195	205	382	270	210	200	
	greywacke	223	203	208	381	309	235	220	
	basaltic rocks	195	FN	FN	291	349	FN	FN	
	Average of fraction prices in the region	**199**	**199**	**207**	**351**	**309**	**223**	**210**	**243**
Pardubice	gneiss	240	180	207	410	340	275	250	
	granitic rocks	211	205	211	405	330	267	211	
	basaltic rocks	240	230	225	430	320	235	230	
	hornfels	FN	205	200	335	310	240	225	
	Average of fraction prices in the region	**230**	**205**	**211**	**395**	**325**	**254**	**229**	**264**
Olomouc	limestone	227	206	210	407	309	217	206	
	greywacke	210	205	198	408	340	247	225	
	gneiss	230	229	229	459	351	229	206	
	amphibolite	221	209	221	376	313	246	212	
	Average of fraction prices in the region	**222**	**212**	**215**	**413**	**328**	**235**	**212**	**262**
Central Bohemia	limestone	202	190	194	364	294	260	255	
	gneiss	230	255	260	440	360	265	245	
	granitic rocks	180	210	220	386	342	264	285	
	amphibolite	170	215	215	435	325	255	218	
	hornfels	150	210	205	347	290	252	285	
	basaltic rocks	230	232	230	380	343	293	290	
	opoka-sandstone	FN	FN	220	FN	FN	FN	150	
	serpentine	150	159	165	291	241	204	200	
	skarn	165	245	230	395	3340	280	240	
	Average of fraction prices in the region	**185**	**215**	**215**	**380**	**692**	**259**	**241**	**312**
Prague	basaltic rocks	210	215	FN	380	320	315	325	
	limestone	240	240	240	420	340	300	FN	
	Average of fraction prices in the region	**225**	**228**	**240**	**400**	**330**	**308**	**325**	**294**
South Bohemia	limestone	175	253	263	314	FN	259	222	
	greywacke	220	185	190	420	250	230	220	
	granitic rocks	213	243	235	419	318	260	215	
	granulite	235	277	277	415	322	272	218	
	Average of fraction prices in the region	**211**	**240**	**241**	**392**	**297**	**255**	**219**	**265**
Ústí nad Labem	granitic rocks	185	235	200	FN	FN	FN	330	
	basaltic rocks	240	250	227	378	326	255	260	
	Average of fraction prices in the region	**213**	**243**	**214**	**378**	**326**	**255**	**227**	**265**
Liberec	basaltic rocks	206	250	258	438	375	267	260	
	Average of fraction prices in the region	**206**	**250**	**258**	**438**	**375**	**267**	**260**	**293**
Vysočina	gneiss	177	206	212	401	315	259	252	
	granitic rocks	206	205	203	396	308	255	220	
	amphibolite	270	240	240	480	390	320	265	
	Average of fraction prices in the region	**218**	**217**	**218**	**426**	**338**	**278**	**246**	**277**
Hradec Králové	limestone	387	259	232	374	353	FN	189	
	gneiss	223	285	284	480	411	363	250	
	granitic rocks	210	215	220	425	335	283	260	
	amphibolite	270	215	245	460	380	295	260	
	basaltic rocks	210	205	206	320	265	297	240	
	Average of fraction prices in the region	**260**	**236**	**237**	**412**	**349**	**310**	**240**	**292**
Zlín	opoka-sandstone	FN	295	290	470	FN	335	FN	
	Average of fraction prices in the region	FN	**295**	**290**	**470**	FN	**335**	FN	**348**

Explanations:

FN: frction is not produced
LK: quarry stone
limestone: limestone+dolomite+marble
basaltic rocks: melaphyre+spilite+basalt+phonolite
granitic rocks: granodiorite+granite+syenite+diorite+porphyry
gneiss: orthogneiss+paragneiss

Average domestic prices of crushed stone in 2021 – by regional units

2021	Average prices of (listed) fractions (CZK/t)																		In regions
REGION	0-4 mm	0-8 mm	0-16 mm	0-32 mm	0-63 mm	0-125 mm	4-8 mm	8-16 mm	8-32 mm	11-22 mm	16-22 mm	16-32 mm	32-63 mm	63-125 mm	unsorted material	pit material	over - burden	for backfill	
Hradec Králové	223	FN	211	226	236	185	438	362	FN	372	FN	306	298	275	302	350	FN	50	**274**
Plzeň	231	242	FN	228	214	205	391	322	FN	334	329	317	256	233	221	379	87	95	**255**
Central Bohemia	182	186	205	209	212	178	375	316	FN	320	306	296	257	234	275	317	80	90	**238**
Liberec	196	182	FN	250	253	200	448	375	450	356	351	358	277	268	243	370	110	86	**281**
Pardubice	226	175	FN	200	213	184	410	339	280	230	280	255	270	237	227	306	60	95	**235**
Ústí nad Labem	240	215	FN	260	238	228	377	326	275	321	310	316	255	244	266	285	FN	90	**265**
South Moravia	171	FN	FN	194	203	186	384	319	FN	278	290	261	239	230	224	248	75	87	**226**
Karlovy Vary	266	185	240	232	213	204	350	288	295	278	285	271	258	233	208	348	100	90	**241**
South Bohemia	219	171	187	246	241	230	415	325	282	316	315	307	264	251	218	250	90	106	**246**
Olomouc	205	202	229	200	194	184	406	334	259	313	272	299	246	240	227	341	80	90	**240**
Zlín	FN	150	FN	295	290	270	470	FN	FN	FN	FN	360	335	380	FN	490	FN	70	**311**
Moravia and Silezia	217	180	132	203	208	154	385	317	FN	319	299	274	235	212	222	269	115	90	**225**
Vysočina	176	153	180	211	210	202	406	318	195	306	293	287	263	245	244	297	70	90	**230**
Prague	225	FN	210	228	240	270	398	330	FN	FN	320	325	308	298	325	FN	FN	FN	**290**
Czech Republic - total	**214**	**186**	**199**	**227**	**226**	**206**	**404**	**329**	**291**	**312**	**304**	**302**	**269**	**256**	**246**	**327**	**87**	**87**	213

Explanation: FN – fraction is not produced

7. Mining companies in the Czech Republic as of December 31, 2021

Crushed stone – registered deposits
EUROVIA Kamenolomy a.s.
Českomoravský štěrk a.s.
KAMENOLOMY ČR s.r.o.
KÁMEN Zbraslav a.s.
COLAS CZ a.s.
Kámen a písek s.r.o.
M – SILNICE a.s.
GRANITA s.r.o.
Basalt s.r.o.
Basalt CZ s.r.o.
Berger Bohemia a.s.
Lom Klecany s.r.o.
Kámen Brno s.r.o.
Skanska a.s.
ZAPA beton a.s.
Žula Rácov s.r.o.
BES s.r.o.
CEMEX Sand k.s.
RENO Šumava a.s.
C4SC78 s.r.o.
Rosa s.r.o.
LOMY MOŘINA s.r.o.
Českomoravský cement a.s.
Silnice Čáslav – Holding a.s.
Ludvík Novák
SHB s.r.o.
Moravské kamenolomy s.r.o. Froněk s.r.o.
Hutira – Omice s.r.o.
BÖGL a KRÝSL k.s.
Froněk s.r.o.
BISA s.r.o.
FORTEX STAVBY s.r.o.
ZD Šonov u Broumova
RESTA DAKON s.r.o.
Kalivoda DC s.r.o.
Madest s.r.o.
LOM DEŠTNO a.s.
KARETA s.r.o.
Kamenolom Číměř s.r.o.
DOLESA s. r. o.
ERB invest s.r.o.
Kozákov – družstvo
EKOZIS s.r.o.
František Matlák
LB s.r.o.
Quarzit Quarry a.s.
HERLIN s.r.o.
SATES ČECHY s.r.o.
EKOSTAVBY Louny s.r.o.
NATRIX a.s.
PEDOP s.r.o.
GRANIO s.r.o.
Stavební recyklace s.r.o.
UNIKOM a.s.
Kamenolom KUBO s.r.o.

Crushed stone – non–registered deposits
Českomoravský štěrk a.s.
Kámen a písek s.r.o.
COLAS CZ a.s.
Silnice Morava s.r.o.
KAMENOLOMY ČR s.r.o.
Sokolovská uhelná p.n. a.s.
EUROVIA Kamenolomy a.s.
ZAPA beton a.s.
ZETKA Strážník a.s.
Basalt s.r.o.
LOM DEŠTNO a.s.
Stavební recyklace s.r.o.
KÁMEN Zbraslav a.s.
Moravské kamenolomy s.r.o.
SP Bohemia k.s.
ZUD a.s.
TS služby s.r.o.
LB s.r.o.
SENECO s.r.o.
Stavoka Kosice a.s.
Lesostavby Frýdek–Místek a.s.
Obec Hošťálková
Kamenolom Žlutava s.r.o.
Ligranit a.s.
EKOZIS s.r.o.
GRANITA Lomy s.r.o.
UNI – STONE JÁCHYMOV s.r.o.
Vojenské lesy a statky ČR s.p.
Lesní družstvo obcí

8. World production and world market prices

Mine production of the crushed stone is frequently reported together with sand and gravel under the term aggregates.

Crushed stone prices are not formed on the international market. Neither indicative regional prices are quoted.

Dimension stone

1. Characteristics and use

The raw materials are all types of solid rocks of magmatic, sedimentary and metamorphic origin, which are block workable and their properties are suitable either for rough stone production (curbs, paving blocks, building blocks, etc.) or for noble production (stonework, stone sculptures and special works). The decisive factors for rough production include the mineralogical-petrographic composition, physical-mechanical properties, structure, texture, blockiness, secondary transformations and more. In the case of raw materials for noble production, the appearance, colour, polishability and durability of the rock are evaluated. Negative properties include weathering and secondary transformations, crushed zones, intercalations of unsuitable rocks, etc.

Reserves

They are extensive worldwide.

Uses

In construction, stonework and sculpture.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

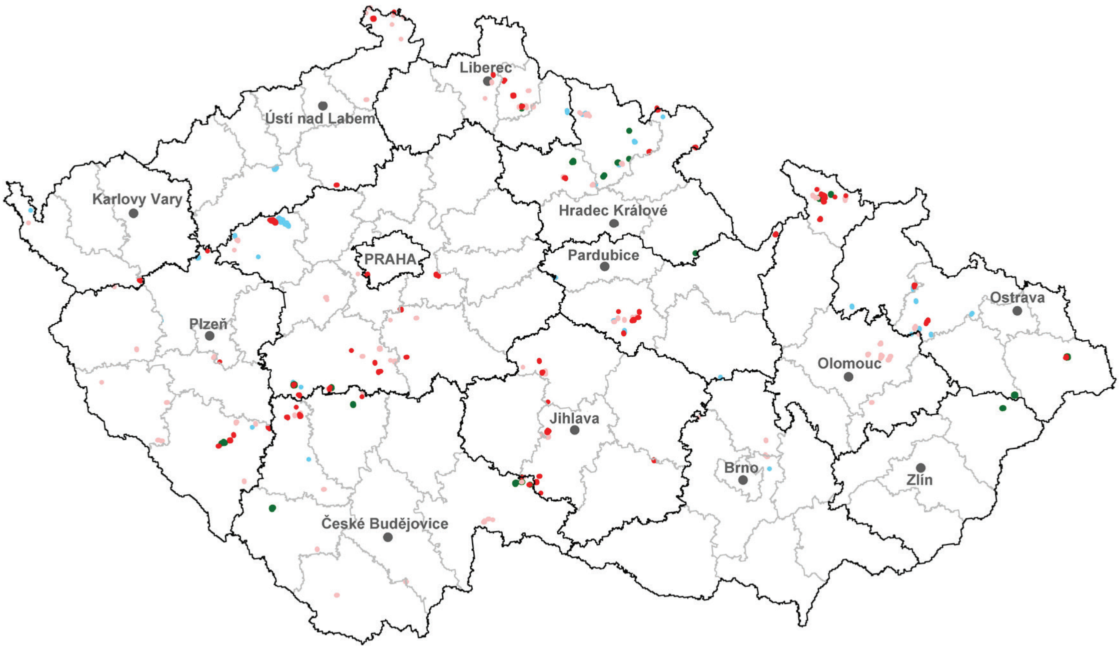
2. Mineral resources of the Czech Republic

At present, deep igneous rocks (especially granitoid rocks) are the most widely used in the Czech Republic as a stone for rough and noble stonemasonry production, which have long accounted for approximately 85–90% of the volume of mined reserved deposits. They have a more than 50% share in the total geological reserves. These rocks account for about 85% of total mining at reserved deposits and for about 60–70% of total mining at non-reserved deposits. Roughly 10% of the extraction from reserved deposits is occupied by sandstones, in the case of non-reserved deposits it is around 30% of the extraction volume. The proportion of marbles is low – around 1 to 2%.

- For rough stone production (cubes, curbs, bollards, stairs, plinths, etc.) mainly deep igneous rocks were and are used; other rocks (columnar basalts, vein rocks) were and are used much less. The deposits are, similarly to the building stone, bound to the Central Bohemian and Moldanubian pluton, the Nasavrky massif, or other plutonic bodies of the Bohemian massif (Štěnovice massif, Žulová pluton, Čistá-Jesenice massif, etc.).
- Deep igneous rocks and marble are the most used for noble production. The most used are the light rocks – granites and granite-diorites, which occur in Bohemia in the Central Bohemian and Central Moldanubian pluton, in the Štěnovice, Krkonoše-Jizera, Čistá-Jesenice and Nasavky massifs and in Moravia in the Třebíč and Žulová massifs. Dark igneous rocks are of minor importance – diabases, diorites and gabbro, which are bound to the basic bodies of the Central Bohemian pluton, the Kdyně and Lusatian massifs, etc. These rocks are used for tiling (including polished tiling), paving, monuments and in stone sculpture.
- Neovolcanics are not very suitable, with the exception of some trachytes of the Central Bohemian Uplands and the Doupov Mountains, which are used in sculpture and for cut tiles.

- Of the sedimentary rocks, sandstone and arkose are of great importance. In Bohemia, these are the Cenomanian sandstones from the eastern surroundings of Prague, Hořice and Broumov. Less significant are the Triassic and red Permian sandstones from the foothills of the Giant Mountains. In Moravia, these are Cretaceous Těšín sandstones, or also the red Perm sandstones of the Tišnov region. Sandstones are used for the production of cut and ground tiles. The Devonian limestones of the Barrandien and the Moravian Karst are equally popular raw materials for their versatile range of uses (cladding material, conglomerates, terrazzo, etc.). Pleistocene travertines were mined in the Přerov region for internal cladding, terraces and conglomerates. The shales of the Moravian-Silesian Paleozoic are used as cladding, covering and paving material, expandites and fillers. Kulm greywackes were often used for rough stonemasonry (cubes, curbs).
- Of the metamorphic rocks, crystalline limestones and dolomites (marbles) are the most used – for polished tiles, paving, terrazzo, conglomerates and in sculpture. They occur abundantly in the Bohemian Forest and Czech branches of the Moldanubian, Krkonoše-Jizera and Orlicko-Kladsko crystalline complex, Svratka anticline, Silesicum, in the Branná formation (Silesia). The phyllites of the Proterozoic of Western Bohemia (the Střela Valley) and the Železný Brod crystalline complex, as well as the slate curling iron in northern Moravia and Silesia, are used as roofing and cladding (the waste is used as a filler). Serpentines mined in Moravia and western Bohemia were and are still used.

3. Registered deposits and other resources of the Czech Republic



- reserved deposits – exploited (54)
- reserved deposits – unexploited (104)
- non-reserved deposits – exploited (21)
- non-reserved deposits – unexploited (49)

There are many registered dimension stone deposits in the Czech Republic and therefore they are not listed.

4. Basic statistical data of the Czech Republic as of December 31

Reserved deposits: Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	159	159	158	158	158
exploited	63	64	63	64	54
Total mineral *reserves, ths m^3	18, 972	181,568	181,383	184,236	182,835
economic explored reserves	77,590	77,688	77,511	78,320	78,031
economic prospected reserves	64,888	64,386	64,380	66,427	65,753
potentially economic reserves	39,494	39,494	39,492	39,489	39,051
exploitable reserves	89,048	74,519	77,407	108,505	79,798
Mine production in reserved deposits, ths m^3	111	116	117	135	125

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	ths m^3	5 043	3 026	3 026	3 026	3 026
P_2,	ths m^3	12 701	–	–	–	–
P_3		–	–	–	–	–

Non-reserved deposits: Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	68	68	69	69	70
exploited	24	22	21	21	21
Total mineral *reserves, ths m^3	33,152	33,256	33,250	26,096	26,520
economic explored reserves	2,164	2,158	2,152	2,132	2,101
economic prospected reserves	28,032	28,142	28,124	21,008	21,463
potentially economic reserves	2,956	2,956	2,956	2,956	2,956
exploitable reserves	1,331	1,610	1,192	1,875	1,931
Mine production in non-reserved deposits, ths m^3 a)	33	18	16	47	62

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

a) *estimate*

5. Foreign trade

2514 – Slate, also rougly worked or cut

		2017	2018	2019	2020	2021
Import	t	13,954	16,873	12,328	10,311	12,215
Export	t	5,483	6, 807	7,476	7,066	9,477

2514 – Slate, also rougly worked or cut

		2017	2018	2019	2020	2021
Average import prices	CZK/t	1,316	1,254	1,391	1,260	1,354
Average export prices	CZK/t	1,091	1,003	1,118	1,088	1,329

2515 – Marble, travertine, ecaussine and other calcareous stone

		2017	2018	2019	2020	2021
Import	t	4,402	4,019	4,509	5,198	5,513
Export	t	1	1	23	39	24

2515 – Marble, travertine, ecaussine and other calcareous stone

		2017	2018	2019	2020	2021
Average import prices	CZK/t	8,002	7,368	8,956	8,989	8,384
Average export prices	CZK/t	63,701	82,969	37,815	48,627	76,749

2516 – Granite, porphyry, basalt, sandstone and other stone

		2017	2018	2019	2020	2021
Import	t	5,640	8,266	10,163	5,344	5,019
Export	t	15,972	11,856	3,498	2,880	3,339

2516 – Granite, porphyry, basalt, sandstone and other stone

		2017	2018	2019	2020	2021
Average import prices	CZK/t	6,597	5,323	7,267	8,563	11,020
Average export prices	CZK/t	2,021	2,675	4,070	4,245	5,365

6801 – Setts, curbstones and flagstones of natural stone (except slate)

		2017	2018	2019	2020	2021
Import	t	14,597	28,747	22,079	20,859	29,325
Export	t	56,198	43,223	31,731	33,823	34,981

6801 – Setts, curbstones and flagstones of natural stone (except slate)

		2017	2018	2019	2020	2021
Average import prices	CZK/t	2,069	2,492	2,189	2,479	2,533
Average export prices	CZK/t	2,055	2,202	2,367	2,554	2,455

6802 – Worked monumental and crushed stone (except slate) and stonework

		2017	2018	2019	2020	2021
Import	t	27,255	25,734	27,301	25,392	26,962
Export	t	38,161	34,777	29,279	51,707	71,629

6802 – Worked monumental and crushed stone (except slate) and stonework

		2017	2018	2019	2020	2021
Average import prices	CZK/t	14,455	13,606	14,530	14,783	16,983
Average export prices	CZK/t	6,819	5,292	6,253	4,727	4,088

6803 – Worked slate and articles of slate or of agglomerated slate

		2017	2018	2019	2020	2021
Import	t	2,141	2,554	1,976	1,817	1,482
Export	t	105	124	79	90	133

6803 – Worked slate and articles of slate or of agglomerated slate

		2017	2018	2019	2020	2021
Average import prices	CZK/t	14,917	13,650	21,318	19,505	34,521
Average export prices	CZK/t	93,511	93,263	150,651	135,629	147,490

6. Prices of domestic market

Product specification			Unit	2016	2017	2018	2019	2020
greyish blue Hlinec granite	cobblestones		CZK/t	2,100–2,550	2,150–2,600	2,150–2,600	2,250–2,800	2,250–2,800
	margin stones		CZK/bm	320–400	320–450	320–450	340–450	340–450
	cleaved prisms		CZK/m²	2,100	2,100	2,100	2,100	2,100
	curbstones		CZK/bm	1,000–1,200	1,000–1,200	1,000–1,200	1,000–1,200	1,000–1,200
	slabs	polished, thickness 2–8 cm	CZK /m²	1,800–3,800	1,800–3,800	1,800–3,800	1,800–3,800	1,800–3,800
		emery grounded, thickness 2–8 cm	CZK /m²	1,600–3,600	1,600–3,600	1,600–3,600	1,600–3,600	1,600–3,600
		sand blasted finish, thickness 2–8 cm	CZK /m²	1,400–1,200	1,400–1,200	1,400–1,200	1,400–1,200	1,400–1,200
		formatted suitable as pavement, thickness 3 cm	CZK /m²	1, 560–2,260	1, 560–2,260	1,560–2,260	1,560–2,260	1,560–2,260
Granite Kozárvice Chlum Řečice		cobblestones 18/18–4/6	CZK/t	2,000–2,400	2,000–2,400	2,000–2,500	2,600	2,800
		curbstones 10/20/40–20/10/40	CZK/t	2,300 –2,400	2,300 –2,400	2,500	2,500–2,800	3,000
		margin stones	CZK/t	350	350	350	350	350
		blocks 0.5–0.99 to 2.0–2.49 m³	CZK /m³	5,500, 7,600	5,500, 7,600	5,500, 7,600	5,500, 7,600	5,500, 7,600
		blocks 2.5–2.99 to 4.0–5.0 m³	CZK /m³	8,500, 9,500	8,500, 9,500	8,500, 9,500	8,500, 9,500	8,500, 9,500
light Silesian granite	cobblestones		CZK/t	1,900–3,000	1,900–3,000	1,900–3,000	2,400–3,000	2,450–2,750
	margin stones		CZK/bm	300–330	300–330	300–369	400–450	500–520
	cleaved prisms		CZK/m²	1,650	1,650	1,650	2,000	2,200
Mrákotín type granite – pavement slabs		sand blasted finish, thickness 2–8 cm	CZK/m²	1,450–2,250	1,450–2,250	1,320–2,500	1,500–2,600	1,600–2,750
		emery grounded, thickness 2–8 cm	CZK/m²	1,580–2,480	1,580–2,480	1,600–2,500	1,700–2,850	1,750–3,000
		polished, thickness 2–8 cm	CZK/m²	1,900–2,700	1,900–2,700	2,000– 3,200	2,100–3,200	2,200–3,3500
granite blocks			Kč/m³	<1,5 m³ = 7 000 >1,5 m³ = 9 000	<1,5 m³ = 7 000 >1,5 m³ = 9 000	<1,5 m³ = 8 000 >1,5 m³ = 10 000	<1,5 m³ = 8 500 >1,5 m³ = 11 000	<1,5 m³ = 8 700 >1,5 m³ = 11 500
sandstone – cut slabs	thickness 5 cm		CZK/m²	1,000–1,930	1,000–1,930	1,000–1,930	1,000–1,930	1,000–1,930
	thickness 10 cm		CZK/m²	2,770–3,410	2,770–3,410	2,770–3,410	2,770–3,410	2,770–3,410
	thickness 15 cm		CZK/m²	4,190–5,180	4,190–5,180	4,190–5,180	4,190–5,180	4,190–5,180
marble – pavement	cut	Supíkovice marble	CZK/m²	280–1,100	280–1,100	280–1,100	320–1,200	350–1 300
		Lipová marble	CZK/m²	280–1,190	280–1,190	280–1,190	340–1,250	360–1 300
	smoothed	Supíkovice marble	CZK/m²	360–1,240	360–1,240	360–1,240	380–1,300	380–1 300
		Lipová marble	CZK/m²	360–1,350	360–1,350	360–1,350	380–1,400	380–1 400
	polished	Supíkovice marble	CZK/m²	390–1,280	390–1,280	390–1,280	420–1,300	420–1 300
		Lipová marble	CZK/m²	390–1,390	390–1,390	390–1,390	420–1,450	420–1 450
basalt	column 131–160 cm	quarry Soutěsky	Kč/t	–	5,000	5,000	–	–
	paving thick 2 cm	quarry Soutěsky	Kč/m²	–	650	650	–	–
	paving thick 10 cm	quarry Soutěsky	Kč/m²	–	750	750	–	–

Notice: bm (běžný metr) – running metre

7. Mining companies in the Czech Republic as of December 31, 2021

Dimension stone – reserved deposits
Slezské kamenolomy a.s.
RESTA DAKON s.r.o.
MEDIGRAN s.r.o.
Plzeňská žula a.s.
Granit Lipnice s.r.o.
SATES ČECHY s.r.o.
HERLIN s.r.o.
Průmysl kamene a.s.
ABAKRON s.r.o.
KÁMEN OSTROMĚŘ s.r.o.
Ligranit a.s.
ČESKÁ ŽULA s.r.o.
Lom Drahenický Málkov s.r.o.
Granit Zedníček s.r.o.
Kámen Hudčice s.r.o.
GRANIT-ZACH s.r.o.
RESTA DAKON s.r.o.
Těžba nerostů a.s.
ABAKRON s.r.o.
LOM DEŠTNO a.s.
KAVEX – Granit Holding a.s.
Důl Svatoňovice a.s.
Lom Matula Hlinsko a.s.
GRANITES s.r.o.
GRANIO s.r.o.
Třebocký lom CZ s.r.o.
KÁMEN OSTROMĚŘ s.r.o.
Kamenoprůmysl. závody s.r.o.
Krákorka a.s.
M. & H. Granit s.r.o.
Mšenské pískovce s.r.o.

Dimension stone – non-reserved deposits
RENO Šumava a.s.
Lom Kozárovice a.s.
PROFISTAV Litomyšl a.s.
Josef Máca
KOKAM s.r.o.
Lom Horní Dvorce s.r.o.
WÜHNANOFF s.r.o.
SATES ČECHY s.r.o.
Žula s.r.o.
Jiří Sršeň
Lesostavby Frýdek-Místek a. s.
HERLIN s.r.o.
SPONGILIT PP s.r.o.

8. World production and world market prices

Global mining of decorative stone is not statistically recorded and many states do not monitor it at all. The most important producer of dimension stone in Europe is Italy, in the world it is the US, Brazil, and China.

Project EuroLithos, which was part of the GeoERA program was finalised during 2021. It mapped decoration and dimension stone deposits in 14 European countries and the results including a database and an interactive map can found at https://www.eurolithos.org/ and https://geoera.eu/projects/eurolithos1/.

Dimension stone is subject to global trade while prices are determine by corporate price lists. Dimension stone prices depend on the quality and colour of the rock and the degree of processing. They can be estimated by price levels in the US market (*Source: https://www.usgs-gov/centers/nmic/dimension-stone-statistics-and-information. Advance Data Release of the 2020 Annual tables. Posted: November 17, 2021)*:

Dimension stone sold or used in the US in 2020, classification by types

	Amount, t	Value, ths USD	Average price, USD/t
Granite	436,000	110,000	258
Limestone	1,140,000	195,000	171
Marble	35,300	10,600	300
Sandstone	493,000	51,500	104
Slate	43,200	21,400	495
Other types of stone	204,000	35,700	177

Dimension stone export from the US in 2020, classification by types

	Amount, ths t	Value, ths USD	Average value, USD/t	Main destination, by value
Marble, travertine, alabaster worked (further worked than simply cut with a flat surface)	93	8,230	88	Canada, 67%
Marble, travertine, crude or roughly trimmed	7	7,500	1,071	Italy, 94%
Marble, travertine, merely cut, by sawing or otherwise (blocks or slabs)	5	2,960	592	Canada, 61%
Granite, crude or roughly trimmed	27	7,630	283	China, 45%
Granite, merely cut, by sawing or otherwise (blocks or slabs)	16	5,160	323	Canada, 65%
Slate, worked and articles of slate	2	2,640	1,320	Canada, 40%
Slate, whether or not roughly trimmed or merely cut (blocks or slabs)	2	207	104	UK, 37%
Other calcareous, memorial, or building stone; alabaster (other than marble and travertine; crude, roughly cut or simply cut into blocks or slabs)	19	7,550	397	Canada, 92%
Other monumental or building stone (other than calcareous stone and alabaster, granite, sandstone, slate, dolomite, quartzite, and steatite; crude, roughly trimmed or merely cut into blocks or slabs)	16	4,950	309	Canada, 74%

Dimension stone import in the US in 2020, classification by types

	Unit	Amount	Value, ths USD	Average value, USD/t or USD/ft² (USD/m²)	Main source, by value
Marble and alabaster (simply cut with a flat surface)	tonnes	46,700	35,400	758	Italy, 19%
Roofing slate	mill ft²	739,000	11,100	0.000015 (0.00015)	Spain, 51%
Roughly trimmed or simply cut slate (rectangular blocks or slabs)	mill ft²	6,610	3,120	0.0005 (0.005)	India, 36%
Worked slate and articles of slate products and other products (other than roofing products, including agglomerated slate)	mill ft²	72,500	35,800	N	China, 49%
Travertine, monumental or building stone and products thereof (simply cut with a flat surface, other than tiles and granules)	mill ft²	8,180	6,990	0.0009 (0.01)	Italy, 41%%
Travertine, worked monumental or building stone (dressed or polished but not further worked)	mill ft²	8,100	5,870	0.0007 (0.008)	Turkey, 37%

Note: ft^2 – square foot; 1 ft^2 = 0.092903 m^2

Salient statistics USA – dimension stone sold or used by producers

Year	2017	2018	2019	2020	2021e
Tonnage (kt)	2,880	2,660	2,520	2,350	2,300
Value (mill USD)	453	437	415	424	430
Imports for consumption (mill USD)	2,120	2,090	1,900	1,750	2,300
Exports (mill USD)	69	70	59	47	48
Price	**Variable, depending on type or product**				

Granite only, sold or used by producers

Tonnage (kt)	526	484	430	436	420
Value (mill USD)	115	108	105	110	120
Imports (mill USD)	1,020	915	863	794	890
Exports (mill USD)	22	19	17	13	11
Price	**Variable, depending on type or product**				

e – preliminary values
Source: MCS

Sand and gravel

1. Characteristics and use

Sand and gravel (sometimes called gravel sand) is a mixture of gravel and sand and it is one of the most important raw materials in the building materials industry. It consists of unconsolidated sediments, formed by drift and sedimentation of more or less processed fragments (sand e.g. 0.063 to 2 mm , gravel e.g. 2 to 128 mm) originating from rocks disintegrated by weathering. In their composition, boulders of resistant rocks and minerals (quartz, feldspar, quartzite, lydite, granite, etc.) predominate over the less resistant ones (most crystalline and sedimentary rocks). A mixture of silt and clay is added to them. The main pollutants include humus, clay layers, higher contents of washable particles and sulphur, high contents of unsuitable or weathered grains. Furthermore, opal, chalcedony, hornstone and diatomite – aqueous silicon compounds react with feldspar alkalis to form a silica gel, which absorbs water and causes concrete to crack.

Reserves

They are extensive and inexhaustible worldwide.

Uses

The main use of gravel and sand is given by the size and shape of the grains, the type and structure of the rocks and minerals that make it up. Gravel and sand and gravel are most often used as natural aggregates in construction – for concrete mixtures, drainage and filtration layers, backfills and road stabilisation. Sand is mainly used in construction in mortar and concrete mixtures, as grog in the production of bricks, for plasters, as a filler for excavated spaces, etc.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

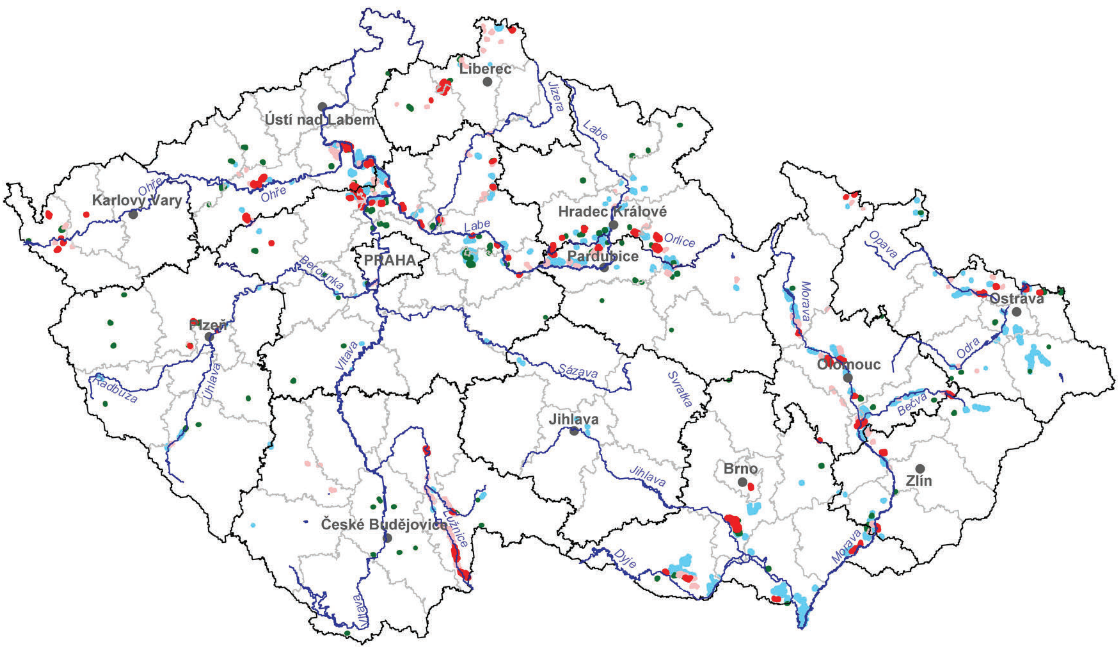
In the Czech Republic, the vast majority of deposits are of Quaternary origin, namely of fluvial origin, much less represented are the deposits of fluviolacustrinal, glacifluvial, glacilacustrinal and aeolian origin. Industrially usable deposits are concentrated mainly in the catchment area of larger rivers.

- The Elbe River Basin – deposits mainly in the right-bank part of the middle course (significant area for Central and Eastern Bohemia) and in the lower course of the Elbe are characterised by well-worked boulders, fluctuations in the ratio of gravel and sand and suitability for concrete-making purposes. There are also significant accumulations in the Orlice and Ohře river basins, the lower reaches of the Cidlina and Jizera rivers and the middle course of the Ploučnice. For concrete-making purposes, the raw material generally requires treatment (washing, sorting).
- The Vltava River Basin – the lower courses of the Vltava and Berounka rivers are important in terms of deposits, but conflicts of interest are frequent. The main deposit area of southern Bohemia are the upper and middle courses of the Lužnice River. The right bank of the Nežárka river is also a promising area.

- The Morava River Basin – on the upper and middle courses of the Morava River, there are accumulations of gravel and sand with a predominance of the coarse fraction; they are suitable to be used in concretes after treatment. Smaller-grained fractions are increasing in the Upper Moravian gorge. The reserves are tied to the valley floodplain, the raw material is suitable for road construction and as mortar sands. An important area for gravel and sand in South Moravia are the middle and lower courses of the river Dyje and its tributaries, especially in the Dyje-Svratka valley basing and in the vicinity of Brno (Svitava, Svratka).
- The Odra River Basin – gravel and sand of the middle reache of the Opava and its confluence with the Odra are important. In terms of quality, the raw material is suitable for road shoulder reinforcement and stabilisation.

Glacigenic deposits in northern Bohemia (Frýdlant area), and the areas around Ostrava and Opava are of minor importance. The aeolian sands of the Elbe and southern Moravia are mainly used for mortar purposes. The proluvial sediments of northern Bohemia, Ostrava, Olomouc, etc are only of local significance. Facially variable Tertiary sands are used somewhat more frequently, e.g. in the Cheb region, in the area of the North Bohemian and South Bohemian basins, or in the area around Pilsen (mortar sands) and especially in Moravia (e.g. Prostějov area, Opava area). Weathered Czech and Moravian Cretaceous sandstones and sands from kaolin floating plants are used for construction purposes.

3. Registered deposits and other resources of the Czech Republic



reserved deposits – exploited (64)
reserved deposits – unexploited (139)
non-reserved deposits – exploited (94)
non-reserved deposits – unexploited (238)

Because of their large number, deposits of sand and gravel are not listed.

4. Basic statistical data of the Czech Republic as of December 31

Reserved deposits: Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	203	203	205	204	203
exploited	69	67	65	63	64
Total mineral *reserves, ths m^3	2,106,593	2,100,538	2,118,240	2,109,426	2,100,932
economic explored reserves	1,070,659	1,072,587	1,073,155	1,066,585	1,076,839
economic prospected reserves	798,996	786,625	803,566	801,125	782,356
potentially economic reserves	236,938	241,326	241,519	241,716	241,737
exploitable reserves	375,261	344,315	397,770	400,093	555,455
Mine production in reserved deposits, ths m^3	6,198	6,499	6,204	6,476	6,562

** See NOTE in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	ths m^3	149,027	149,027	149,027	149,027	149,027
P_2,	ths m^3	946,239	946,239	946,239	946,239	946,239
P_3		–	–	–	–	–

Non-reserved deposits: Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	357	359	343	339	332
exploited	94	93	92	93	94
Total mineral *reserves, ths m^3	2,096,952	2,095,997	2,071,278	2,080,395	2,076,102
economic explored reserves	104,485	104,232	104,040	104,479	104,150
economic prospected reserves	1,756,665	1,755,963	1,731,561	1,740,272	1,736,587
potentially economic reserves	426,488	235,802	235,677	235,644	235,365
exploitable reserves	62,683	57,025	55,169	59,751	60,123
Mine production in non-reserved deposits, ths m^3 a)	4,829	4,875	4,897	4,821	5,270

** See NOTE in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

a) estimate

5. Foreign trade

250590 – Other sand (natural sand of all kinds, also coloured, except sand containing metals and except silica sand and quartz sand)

		2017	2018	2019	2020	2021
Import	kt	189,790	217,493	131,022	159,963	153,723
Export	kt	67,530	103,568	60,227	9,011	1,534

250590 – Other sand (natural sand of all kinds, also coloured, except sand containing metals and except silica sand and quartz sand)

		2017	2018	2019	2020	2021
Average import prices	CZK/t	418	381	491	352	382
Average export prices	CZK/t	209	330	387	1,557	10,785

6. Prices of domestic market

We present the average prices of gravel sands according to the price lists of mining organizations, without taking into account qualitative parameters.

Average domestic prices of sand and gravel in 2021 – by regional units

2021	Average prices of (listed) fractions (CZK/t)																		in regions
REGION	0-1 mm	0-2 mm	0-4 mm	0-8 mm	0-16 mm	0-32 mm	0-63 mm	4-8 mm	8-16 mm	8-32 mm	11-22 mm	16-32 mm	22-63 mm	32-63 mm	unsorted material	pit material	over - burden	for backfill	
Hradec Králové	FN	130	146	135	140	289	318	292	258	FN	338	297	FN	293	110	100	92	85	**202**
Plzeň	145	236	202	137	FN	170	FN	280	319	245	FN	481	290	295	100	FN	80	105	**220**
Central Bohemia	140	186	152	138	FN	230	228	243	257	FN	244	299	FN	268	122	103	100	95	**187**
Liberec	FN	222	170	155	165	140	205	490	475	FN	440	305	FN	310	108	140	90	110	**235**
Pardubice	FN	266	196	227	FN	365	365	342	332	FN	471	345	FN	280	125	90	FN	90	**269**
Ústí nad Labem	240	226	179	185	180	254	237	298	275	FN	360	363	FN	395	169	170	63	86	**230**
South Moravia	142	183	171	195	182	256	215	250	285	FN	292	330	211	290	110	FN	72	80	**204**
Karlovy Vary	FN	195	150	185	190	289	290	280	310	FN	338	297	FN	293	107	100	90	85	**213**
South Bohemia	180	226	215	178	170	145	145	349	337	FN	FN	371	FN	388	125	FN	80	110	**216**
Olomouc	290	283	305	FN	FN	282	329	420	404	FN	335	351	298	320	138	155	70	173	**277**
Zlín	290	280	330	FN	FN	299	329	449	429	FN	458	371	359	335	320	140	FN	FN	**338**
Moravia and Silezia	310	164	235	280	321	271	281	388	378	FN	295	330	FN	304	FN	196	85	102	**263**
Vysočina	In this region is not the sand-gravel material produced																		
Prague	In this region is not the sand-gravel material produced																		
Czech Republic - total	**217**	**216**	**204**	**182**	**193**	**249**	**267**	**340**	**338**	**245**	**357**	**345**	**290**	**314**	**139**	**133**	**82**	**102**	**238**

Explanation: FN - fraction is not produced

Average domestic prices of sand and gravel in 2017–2021 (CZK/t)

Region/year	2017	2018	2019	2020	2021
Hradec Králové	142	147	162	180	202
Plzeň	203	203	203	217	220
Central Bohemia	139	143	153	184	187
Liberec	206	205	208	202	235
Pardubice	167	185	183	289	269
Ústí nad Labem	193	191	190	220	230
South Moravia	154	162	169	202	204
Karlovy Vary	165	182	180	194	213
South Bohemia	185	181	198	191	216
Olomoucký kraj	200	213	233	265	277
Zlín	246	257	273	293	338
Moravia and Silesia	239	249	272	267	263
Vysočina	Sand and gravel are not mined in this region				
Prague	208	208	not mined	not mined	not mined
Czech Republic total	**188**	**194**	**202**	**225**	**238**

7. Mining companies in the Czech Republic as of December 31, 2021

Sand and gravel – registered deposits
Českomoravský štěrk a.s.
České štěrkopísky s.r.o.
LB MINERALS s.r.o.
KÁMEN Zbraslav a.s.
CEMEX Czech Republic s.r.o.
CEMEX Sand k.s.
Družstvo DRUMAPO
Písky – J. Elsnic s.r.o.
TVARBET Moravia a.s.
Kinský dal Borgo a.s.
Písek – Beton a.s.
MIROS Pardubice a.s.
ZAPA beton a.s.
Pískovna Sojovice s.r.o.
Budějovické štěrkopísky s.r.o.
KAMENOLOMY ČR s.r.o.
Městské lesy Hradec Králové a.s
DOBET s.r.o.
Pískovna Černovice s.r.o.
EUROVIA Kamenolomy a.s.
Václav Maurer
NZPK s.r.o.
ZECHMEISTER s.r.o.
Těžba štěrkopísku s.r.o.
Lubomír Kruncl
BS Cost s.r.o
Ladislav Šeda
TAPAS Borek s.r.o.
Oldřich Psotka
Obec Kostomlátky

Sand and gravel – non-registered deposits
České štěrkopísky s.r.o.
SLOVÁCKÁ TĚŽEBNÍ s.r.o.
Vltavské štěrkopísky s.r.o.
CEMEX Sand k.s.
MEASURER s.r.o.

Severočeské pískovny a štěrkovny s.r.o.
Písek Žabčice s.r.o.
ZEPIKO s.r.o.
Písník Kinský s.r.o.
Václav Maurer
Plzeňské štěrkopísky s.r.o.
realma-pískovna Dolany s.r.o.
Pískovna Mistřín s.r.o.
Moravia Tech a.s.
ZS Kratonohy a.s.
Farma U Jezera s.r.o.
Agropodnik Humburky a.s.
Sušárna a.s. Kratonohy
DOBET s.r.o.
SPONGILIT PP s.r.o.
SABIA s.r.o.
Technické služby CZ s.r.o.
Rovina Písek a.s.
BEST a.s.
LIKOD s.r.o.
STAVOKA Hradec Králové a.s.
Vodhosp. stavby Javorník - CZ s.r.o.
MORAS a.s.
Pískovna Pohořelice s.r.o.
VRAMAT CZ s.r.o.
INGEA realizace s.r.o.
INTERAGENCIE Business Services s.r.o.
Martin Čermák
ZEPOS a.s.
Pískovna Klíčany HBH s.r.o.
Ing. Václav Luka
M&M Dresler s.r.o.
Písky - Skviřín s.r.o.
ZAPA beton a.s.
KAMENOLOMY ČR s.r.o.
KORA – VODOSTAVING s.r.o.
Jan Holub
AZS RECYKLACE ODPADU s.r.o
Českomoravský štěrk a.s.
Impectus s.r.o.
Obecní lesy Bludov s.r.o.
Kateřina Honsová
Kobra Údlice s.r.o.
Obec Rabštejnská Lhota
Očenášek - Mikulkam s.r.o.
Ilona Seidlová
Ing. František Klika
Oldřich Psotka
Recyklace-štěrkovna Frýdlant s.r.o.
TAPAS Borek s.r.o.
Technické služby Strakonice s.r.o.
Zemědělské družstvo Kokory
Silnice Čáslav – Holding a.s.
Václav Merhulík

8. World production and world market prices

Sand and gravel extraction is often statistically recorded together with crushed stone extraction under the common term "aggregates".

Sand and gravel prices are not created in the international market. Indicative and regional prices are also not quoted.

MINERALS CURRENTLY UNMINED IN THE CZECH REPUBLIC

MINERALS MINED IN THE PAST WITH RESOURCES AND RESERVES

ENERGY MINERALS

Lignite

1. Characteristics and use

In Czech terminology, lignite is the least coalified type of brown coal (brown coal hemitype), often with larger or smaller fragments of woods and trunks with distinct annual rings. Its combustion heat ($Q_s^{m,af}$) on an anhydrous ashless basis is less than 17 MJ/kg. The internationally recognised boundary between lignite and brown coal has not been established. Around the world, lignite is mostly included in brown coal, but in the Czech Republic it is reported separately.

Reserves

Worldwide 319,879 million tonnes (BP SRWE 2019 – brown coal and lignite combined), of which 28% Russia, 24% Australia, 11% Germany, 9% USA, 3% Indonesia and 3% Turkey. The EU with its 53,356 million tonnes has a share of 17%, and the largest reserves are found in Germany (68% of the EU and 11% of the world), Poland (11% of the EU and 2% of the world), the Czechia, Greece and Hungary (each of these countries having approximately 5% of EU and 1% of world reserves).

Uses

Lignite is used mainly in the energy industry (electricity and heat production).

Classification as critical raw materials for the European Union

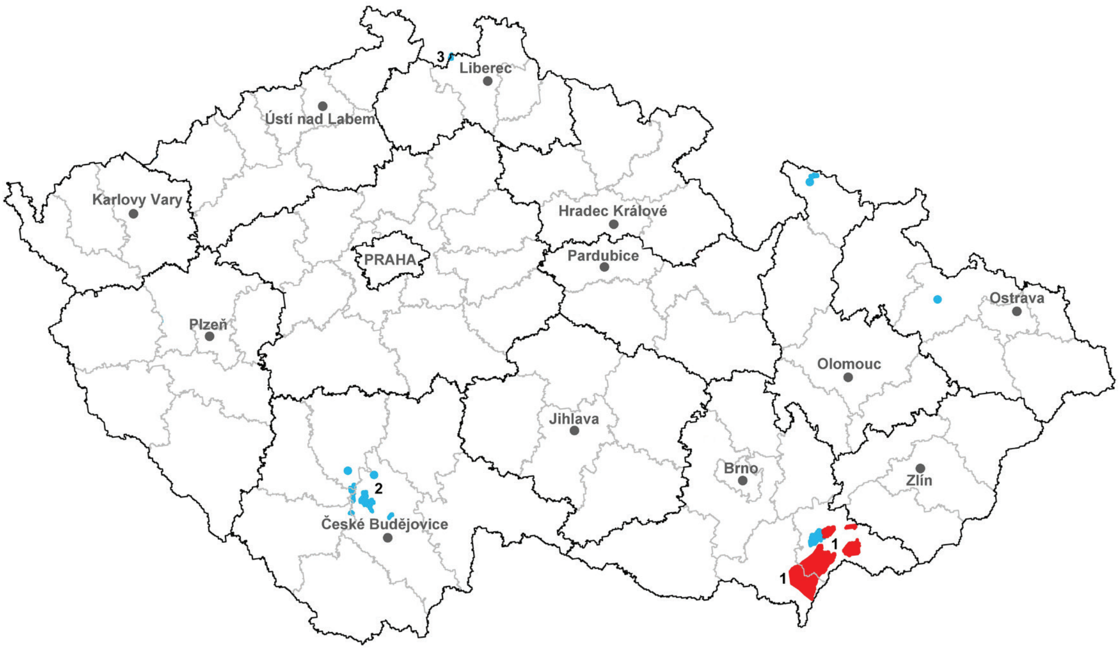
2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

- Significant lignite deposits in the Czech Republic are only at the northern edge of the Vienna Basin, which extends from Austria to southern Moravia. There are two seams in the youngest sediments of Pannonian age. The reserves of the northern Kyjov seam are practically exhausted (the last mine in Šardice was closed at the end of 1992). Since 1994, when mining at the Dubňany deposit was terminated, the reserves of the southern Dubňany seam was mined only in one deep mine – Hodonín-Mikulčice. Its termination was originally expected in 2004, but based on an agreement to extend the contract with ČEZ, mining continued until 2008. Virtually the entire production of this mine was burned at the Hodonín power plant. Economic reserves are reported in four other deposit areas, but their use is not currently being considered. South Moravian lignite is xylodetritic, in places with abundant trunks. It has a high water content from 45 to 49%, ash content A^d varies between 23-26%, the average content of S^d from 1.5 to 2.2% and the calorific value Q_i^r 8 to 10 MJ/kg. In addition, just recently before its mining was terminated, lignite was used for more than just fuel, unfortunately only in small quantities. After crushing and grinding, it was used to produce "teraclean" for soil fertilisation.

- Less significant occurrences of lignite are in the narrow lobular outcrops of the České Budějovice basin. Most of the reserves have been exhausted and the rest are of no economic significance.
- Smaller isolated occurrences of lignite (Miocene) in the Zittau Basin were also largely mined out in the past and the residual reserves are of no economic significance.
- A small occurrence near Uhelná ve Slezsku east of Javorník and in Dolní Životice SW from Opava were also largely mined out in the past.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

Principal areas of deposits presence:

1 Vienna Basin	2 České Budějovice Basin	3 Czech part of the Zittau (Žitava) Basin

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	5	5	5	5	5
exploited	0	0	0	0	0
Total mineral reserves*, kt	997,229	997,229	997,229	997,229	997,229
economic explored reserves	619,652	619,652	619,652	619,652	619,652
economic prospected reserves	229,932	229,932	229,932	229,932	229,932
potentially economic reserves	147,645	147,645	147,645	147,645	147,645
exploitable (recoverable)	1,903	1,903	1,903	1,903	1,903
Mine production, kt	0	0	0	0	0

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Lignite mining ended in 2009.

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	177,351	177,351	177,351	177,351	177,351
P_2,	kt	37,531	37,531	37,531	37,531	37,531
P_3		–	–	–	–	–

5. Foreign trade

No separate tariff item exists for lignite.

6. Prices of domestic market

There are none

7. Mining companies in the Czech Republic as of December 31, 2021

There are none

8. World production and world market prices

World mine production

Worldwide, lignite production is included in brown coal (lignite) production.

Prices of traded commodities

There are no international market for lignite commodities as lignite is generally not traded outside a producing country.

INDUSTRIAL MINERALS

Barite

1. Characteristics and use

Average Ba content (and its extent) in the earth's crust (ppm)
425 (250–600) Ba

Industrially important minerals
Baryte $BaSO_4$. Barium, which is a crucial component of barite, is primarily bound in igneous rocks, which release it during their weathering and it enters sediments and residues.

Industrially important deposit types
1. Submarine hydrothermal-exhalative: Brooks Range Basin, (Alaska – USA), Mangampeta (India), Gongxi (Hunan – China)
2. Hydrothermal veiny and metasomatic: Silvermines (Ireland), Appalachian Quarter (Canada)

Reserves

2021		
Country	**kt**	**% world**
Iran	100,000	14
Kazakhstan	85,000	11
India	51,000	7
Pakistan	40,000	5
China	36,000	5
Turkey	35,000	5
Russia	12,000	2
World*	**740,000**	**100**

** Estimate of the total identified reserves*
Source: MCS 2022

Barite reserves in the EU are known from Spain and Slovakia. Spanish reserves are not published. With their 9.182 kt, Slovakia represents 2.4% of world reserves

Uses
Barite has a wide range of applications due to its properties such as whiteness, high density, chemical resistance, X-ray and gamma ray absorption. It is used in the production of glazes, enamels, paints, special types of glass, plastics, pyrotechnics (signal rockets, detonators, etc.). It also forms part of protective coatings and plasters against X-rays and radioactive radiation,

poisons for rodents and insects. The largest amount of barite is used for heavy flushing in exploration and extraction boring, especially for oil and natural gas.

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – yes, 2020 – yes

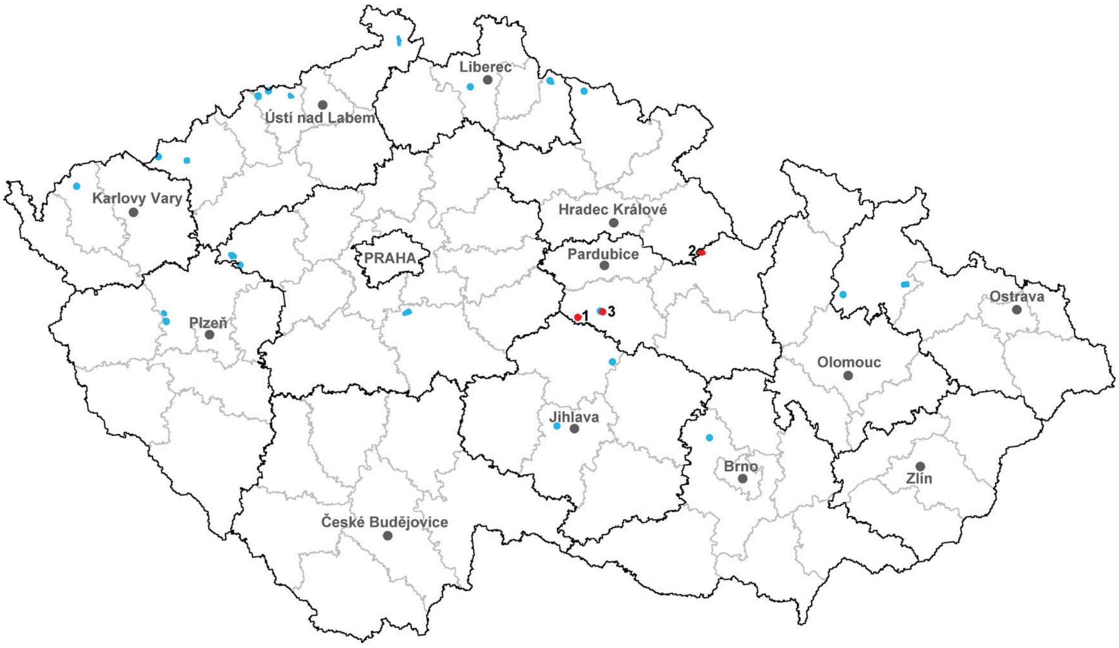
2. Mineral resources of the Czech Republic

The Czech Republic has only smaller deposits and sources of barite. Also, the quality of the raw material is not the highest and ranges on average between 25 and 60% of barite content ($BaSO_4$) as a useful component in individual deposits and resources. Barite deposits in the Czech Republic are of hydrothermal origin, mostly of the veiny or stockwork type, and to a much lesser extent of the metasomatic or stratiform type. They are distributed unevenly in several places in the Bohemian Massif, which is due to the larger number of barite formations of different ages and different deposit types. The most important deposits and sources were in Krušné Hory (the Ore Mountains) (e.g. Kovářská, Mackov, Nakléřov, Moldava-Vápenice), Železné Hory (the Iron Mountains) (e.g. Běstvina, Křižanovice), Krkonoše (the Giant Mountains) (e.g. Harrachov); smaller deposits, resources and occurrences are known from the Jeseníky Mountains (e.g. Horní Benešov), from the Proterozoic of the West (e.g. Pernárec) and Central Bohemia (e.g. Krhanice), Orlické Hory (e.g. Bohousová), the Čistec-Jesenice massif (e.g. Otěvěky), etc.

- Hydrothermal veins in places with polymetallic admixture have a length along the strike varying from tens to hundreds of metres, exceptionally up to 1 km, and thickness from decimetres to several metres, they are characterised by a lenticular and paragraph-like character of the barite filling. They are mostly tied to regional faults, sometimes to lower order faults, mainly in the NW-SE and NNW-SSE direction. The younger polymetallic and the youngest quartz contribution is significant, and it devalues the raw material in the deeper parts (e.g. Mackov, Bohousová). This type includes, for example, the exhausted former Pernarec deposit mined in 1924–1960, as well as deposits, sources and occurrences in Mackov, Bohousová, Nakléřov, etc., where only barite is present or where it strongly predominates. Fluorite is also substantially present in the Běstvina, Moldava, Kovářská, Harrachov, etc. deposits, along with barite. In the Moravicum, the accumulation of barite is known from Květnice near Tišnov, where barite was mined in 1905–1908 and during World War II.
- The stratiform barite type of deposits originated from submarine hydrotherms springing along seabed faults. In the Bohemian Massif, they form layers and lenses in Proterozoic sediments of the islet zone (Krhanice nad Sázavou), the Čistá-Jesenice massif (Čistá, Otěvěky), the Iron Mountains (Křižanovice, Liboměřice) and the Jeseníky Mountains Devonian (Horní Město-Skály, Horní Benešov, where barite was as an accompanying raw material mined 1902–1914 and 1955–1960).

Barite was obtained in the Czech Republic from domestic deposits until 1990 from the Běstvina deposit and until 1991 from the Harrachov deposit. The underground mining significantly prevailed. Resumption of mining is not considered in the near future. The deposits lost their industrial significance, their reserves were gradually re-evaluated and in most cases removed from the Register. Here, as in the case of fluorite, there is plenty of better quality and cheaper raw materials, especially from China.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined

1 Běstvina	2 Bohousová	3 Křižanovice	4 Kovářská

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number [a)]	3	3	3	3	4
exploited	0	0	0	0	0
Total mineral *reserves, kt	569	1,015	1,015	1,015	1,557
economic explored reserves	0	0	0	0	268
economic prospected reserves	0	0	0	0	121
potentially economic reserves	569	1,015	1,015	1,015	1,168
Mine production, kt	0	0	0	0	0

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

a) Deposits with registered barite reserves

5. Foreign trade

251110 – Natural barium sulphate (barite)

		2017	2018	2019	2020	2021
Import	t	8,912	8,618	7,972	7,674	7,401
Export	t	200	167	146	205	272

251110 – Natural barium sulphate (barite)

		2017	2018	2019	2020	2021
Average import prices	CZK/t	10,521	9,998	9,953	10,115	10,873
Average export prices	CZK/t	15,451	15,859	15,530	18,017	15,121

251120 – Natural barium carbonate (witherite)

		2017	2018	2019	2020	2021
Import	t	11	0	0	0	0
Export	t	0	0	0	0	0

251120 – Natural barium carbonate (witherite)

		2017	2018	2019	2020	2021
Average import prices	CZK/t	10 000	–	–	–	–
Average export prices	CZK/t	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

World barite production was as follows in recent years:

	2017	2018	2019	2020	2021[e]
World mine production of barite (according to MCS), kt	8,670	9,180	8,870	6,840	7,300
World mine production of barite (according to WBD), kt	8,955	9,632	9,514	8,086	N

e – preliminary values

Main producers according to MCS

Country	2021[e]	
	kt	%
China	2,800	40
India	1,600	23
Morocco	1,100	16
Kazakhstan	450	6.5
Mexico	320	4.6
Iran	200	2.9
Turkey	180	2.6
Russia	150	2.2
Laos	110	1.6
Pakistan	50	0.7
World	**7,300**	**100.0**

e – preliminary values

Price of traded commodity

Barite is traded in three different quality grades: as a weighting agent in drilling muds and as white paint-grade and chemical-grade barite.

Commodity/Year		2017	2018	2019	2020	2021
Drilling-grade, ground						
Ex-works US, MCS	USD/t	179	176	179	183	180

Fluorspar

1. Characteristics and use

Average F content (and its extent) in the earth's crust (ppm)

500 (270–800) F

Industrially important minerals

Fluorspar CaF_2 (se 48.9% F), fluorapatite $Ca_5(PO_4)_3F$ (with 3.8% F)

Industrially important deposit types

1. Vein-hydrothermal of various origins: La Cuevas (Mexico), Vergenieg, Buffalo (South Africa), Illinois-Kentucky (USA), Shizhuynan, Shuangijangkou (China)
2. Metasomatic: Amba Dongar (India), Kerio Valley (Kenya), Rio Verde, Potosi (Mexico)
3. Sedimentary phosphates: Baja California (Mexico), Bone Valley (USA), Oulad Abdoun (Morocco)

Reserves

2021		
Country	**kt**	**% world**
Mexico	68,000	21.3
China	42,000	13.1
South Africa	41,000	12.8
Mongolia	22,000	6.9
Spain	10,000	3.1
Vietnam	5,000	1.6
USA	4,000	1.3
Iran	3,400	1.1
Mrocco	210	0.1
others	120,000	37.5
World	**320,000**	**100.0**

Source: MCS 2022

In the EU, fluorite reserves are known from Spain and the United Kingdom. They are not published in the United Kingdom.

Uses

In terms of use and quality requirements, we distinguish three basic types of fluorspar:
(a) metallurgical (min. 85% CaF_2, max. 15% SiO_2)

(b) chemical for the production of hydrofluoric acid (min. 97% CaF_2, up to 1.5% SiO_2, 0.1–0.3% S)
(c) ceramic in the production of glass, enamels, etc. (80–96% CaF_2, up to 3% SiO_2).

More than half of the extracted fluorspar is consumed by the chemical industry for the production of F, HF, NaF and cryolite. It is also widely consumed (approx. 1/3 of its production) in metallurgy of aluminium and steel as a flux reducing the melting temperature. It is further used, for example, in the production of cement, in glassmaking (glass with an admixture of 10–30% CaF_2 is opaque, white and opalescent), in the production of enamels and enamels. Polyfluoropolyhalogenalkanes containing bromine, which are used for the production of special extinguishing agents and anaesthetics, have a special status.

Classification as critical raw materials for the European Union
2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes

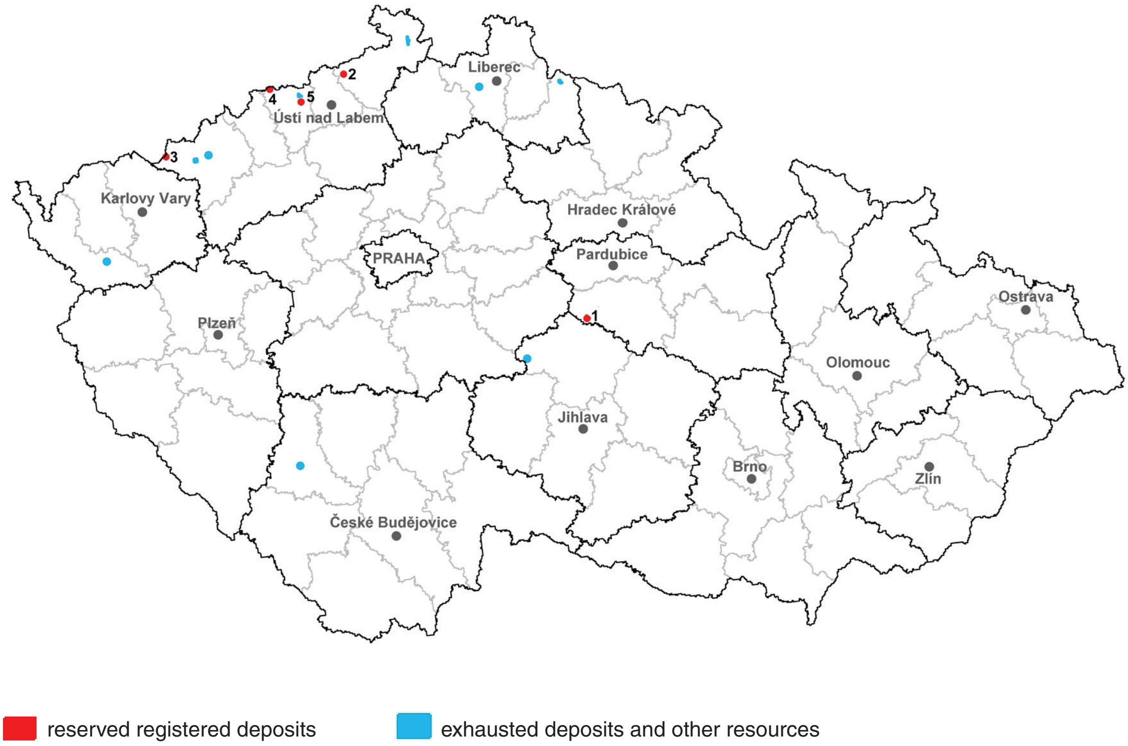
2. Mineral resources of the Czech Republic

The Czech Republic has only smaller deposits and resources of fluorspar. Also, the quality of the raw material is not the highest and ranges on average between 45 and 57% of fluorspar (CaF_2) content as a useful component in individual deposits. All fluorite deposits in the Czech Republic are of hydrothermal origin, venous, stockwork and occasionally also of the impregnation or metasomatic type. They are mostly situated in the peripheral areas of the Bohemian Massif, where they are connected to the deep fault lines of the Ore Mountains (SW – NE) and Elbe-Lusatian direction (NW – SE). The most important deposits and sources are in the Ore Mountains (e.g. Moldava, Kovářská, Krásný Les), and in the Lusatian area of the Czech Cretaceous Basin (Jílové u Děčína-Sněžník) and the Iron Mountains (Běstvina). Smaller sources and occurrences are also found in other places of the Bohemian Massif, e.g. in the Giant Mountains (Harrachov), Ještěd-Kozákov Ridge (Křižany), Slavkovský les (Novina), etc. The only exception among primary hydrothermal deposits is the secondary anthropogenic deposit Proboštov-tailing pond Přítkov, formed by flotation sands after treatment of fluorite ores and concentrates in Sobědruhy.

- Accumulations of fluorspar most often occur together with a substantial proportion of barite (e.g. registered deposits Běstvina, Kovářská and exhausted deposits and resources Krásná Lípa, Hradiště u Vernéřova, Harrachov, Křižany u Liberce, etc.).
- A smaller part of fluorspar accumulations do not contain barites practically at all (e.g. registered deposit Jílové u Děčína and exhausted deposits and resources Blahuňov u Chomutova, Kožlí u Ledče, etc.) or they contain it only in minor amounts (e.g. registered deposit Moldava, exhausted deposit Vrchoslav, etc.).

Industrial fluorspar mining in the Czech Republic began in the early 1950s (except for minor mining in Kožlí near Ledeč nad Sázavou during the two world wars) and lasted until the first quarter of 1994, when the exploitation of the last used Jílové, Běstvina and Moldava deposits was finished. The deep mining method completely prevailed and the fluorspar raw material was processed in the treatment plant in Sobědruhy near Teplice, where two main products were produced from it – floated and lump fluorspar. The renewal of mining in the Czech Republic is not expected in the near future, because there is plenty of higher quality and cheaper raw material on the market, especially from China. The remaining reserves in Czech deposits are mostly not currently economically viable.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined

1 Běstvina
2 Jílové u Děčína
3 Kovářská
4 Moldava
5 Proboštov – tailing pond Přítkov

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number [a)]	5	5	5	5	5
exploited	0	0	0	0	0
Total mineral *reserves, kt	2,210	2,210	2,210	2,210	2,726
economic explored reserves	0	0	0	0	678
economic prospected reserves	32	32	32	32	459
potentially economic reserves	2,178	2,178	2,178	2,178	1,589
Mine production, kt	0	0	0	0	0

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

[a)] *Deposits with registered fluorspar reserves*

5. Foreign trade

252921 – Fluorspar, containing 97 wt % or less of calcium fluoride

		2017	2018	2019	2020	2021
Import	t	2,763	3,432	2,495	2,688	2,387
Export	t	127	242	137	159	459

252921 – Fluorspar, containing 97 wt % or less of calcium fluoride

		2017	2018	2019	2020	2021
Average import prices	CZK/t	5,900	3,432	6,729	8,021	8,805
Average export prices	CZK/t	14,725	2,454	14,000	14,777	12,628

252922 – Fluorspar, containing more than 97 wt % of calcium fluoride

		2017	2018	2019	2020	2021
Import	t	12,311	13,515	12,403	9,519	9,130
Export	t	9,888	11,242	9,562	6,279	6,916

252922 – Fluorspar, containing more than 97 wt % of calcium fluoride

		2017	2018	2019	2020	2021
Average import prices	CZK/t	6,360	6,798	10,064	9,955	8,902
Average export prices	CZK/t	9,063	9,493	12,754	13,377	12,377

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

World fluorspar production in recent years was as follows:

	2017	2018	2019	2020	2021e
World mine production of fluorspar (according to MCS), kt	8,670	9,180	8,870	6,840	7,300
World mine production of fluorspar (according to WBD), kt	8,955	9,632	9,514	8,086	N

e – preliminary values

Main producers according to MCS

Country	2021^{e}	
	kt	%
China	5,400	62.8
Mexico	990	11.5
Mongolia	800	9.3
South Africa	420	4.9
Vietnam	220	2.6
Canada	140	1.6
Spain	130	1.5
Germany	80	0.9
Morocco	80	0.9
Kazakhstan	77	0.9
Pakistan	70	0.8
Iran	56	0.7
World	**8,600**	**100.0**

e – preliminary values

Important producers also include the United States, which does not publish its statistics on fluorspar production. Most American production is a by-product of limestone mining or is produced as a synthetic product of oil refining.

Prices of traded fluorspar commodities

Two grades of fluorspar are listed in market quotations: filtercake for the production of hydrofluoric acid and metallurgical fluorspar.

Commodity/year	2017	2018	2019	2020	2021
Average price USA market, CIF – acid grade (MCS), USD/t	267	276	304	310	330
Average price USA market, CIF – metallurgical grade (MCS), USD/t	237	258	292	149	160
Yearly average import price into the Czech Republic (CSO) from Germany, both qualities total, CZK/t	6,181	6,521	9,916	10,438	9,667

Graphite

1. Characteristics and use

Average C content (and its extent) in the earth's crust (ppm)

(200–800) C

Industrially important minerals

Graphite is one of the naturally occurring forms of carbon (C). It is an important technical mineral. According to the size of the flakes, a distinction is made between "flake" graphite, macrocrystalline with a flake size above 0.1 mm and "amorphous" – crypto to microcrystalline below 0.1 mm, which appears as a solid. The division of crystalline graphite into large, medium and small flakes is a commercial division which has no general rules and varies according to the producer.

Industrially important deposit types

1. Orogenically metamorphic: Kaiserberg (Austria), Graphite Lake (Canada), Moldanubian and Moravian-Silesian deposits of the Bohemian Massif
2. Contact metamorphic: La Colorada (Mexico)
3. Epigenetic: Kahatagaha, Bogala (Sri Lanka)

All rocks whose essential part is graphite and from which it can be obtained by their treatment are considered raw graphite materials.

Reserves

2021		
Country	**kt**	**% world**
Turkey	90,000	25.7
China	73,000	20.9
Brazil	70,000	20.0
Madagascar	26,000	7.4
Mozambique	25,000	7.1
Tanzania	18,000	4.9
India	8,000	2.3
Czech Republic*	7,900	2.3
Uzbekistan	7,600	2.2
Mexico	3,100	0.9
North Korea	2,000	0.6
Sri Lanka	1,500	0.4
Norway	600	0.2
World	****330,000**	**100.0 own estimate**

2021			
Country	**Mill t**	**% world**	**% EU**
EU	8,500	2.43	100.0
Czech Republic*	7,900	2.26	92.9
Norway	600	0.17	7.1
Austria	–	–	–
Germany	–	–	–

** Bilance zásob k 1. 1. 2022 (national Register of Reserves as of 1. 1. 2022)*
*** own estimate*
European Minerals Yearbook – version 2022

Uses

Foundry and metallurgy, electrical engineering, electrochemistry, chemical, missile and armaments industries, nuclear energy, production of refractory materials, lubricants and protective coatings, pencils, fibres, synthetic diamonds.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes

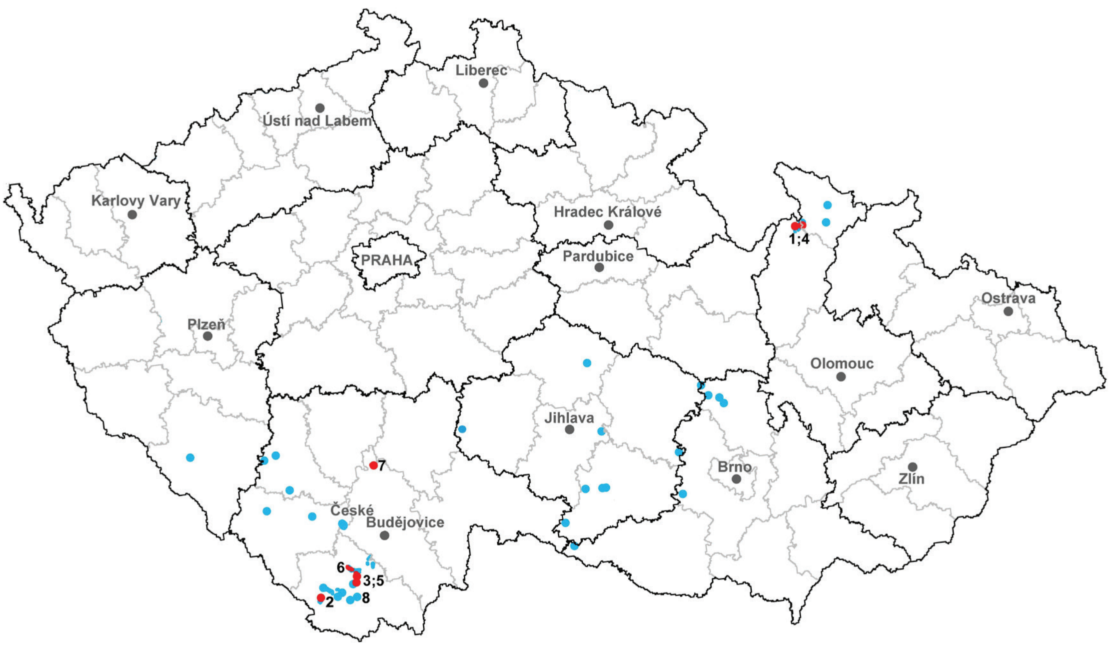
2. Raw material resources of the Czech Republic

In the Czech Republic, there are only smaller deposits and sources of graphite. The quality of the raw material also fluctuates and the graphite contents (C_{graph}) mostly range between 20–40% in deposits and sources of amorphous graphite and between 10–20% in deposits and sources of crystalline graphite. All graphite deposits in the Czech Republic are of the metamorphogenic genetic type. It was formed during the regional metamorphosis of clay-sand sediments with a higher content of biogenic material, which is evident from the increased content of S, P, V and the frequent presence of limestones. Deposits occur in the Bohemian Massif, namely in the Moldanubicum, Moravicum and the Silesian Block.

- The most important deposits and sources are found in the Moldanubicum, especially in the variegated group of Český Krumlov, with crystalline, amorphous and mixed graphite. The most important deposits of crystalline raw material were Český Krumlov-Městský vrch and Lazec, where mining was terminated in the second half of 2003. Amorphous or mixed raw material prevailed in the deposits and sources of Bližná, Český Krumlov-Rybářská ulice, Spolí, Mokrá, etc. The diverse Sušice-Votic group is less significant with the occurrence of the only deposit of crystalline graphite in Koloděje nad Lužnicí-Hosty, which was mined until 1967 (and there is currently a plan to use it again for surface mining). In the past, the occurrence near Černovice was mined in the variegated zone of the Chýnov micaschists, which is no longer of importance as a deposit. South Bohemian raw graphite materials have the nature of graphite-rich gneisses, quartzites or carbonates. Smaller occurrences, nowadays without industrial significance, are also known from the Moravian Moldanubicum (e.g. Lesná, Lubnice, Louka, Římov, etc.).
- The deposits of the Moravian-Silesian region occur in the area affected by a lower degree of metamorphosis. Graphite has a lower degree of crystallinity (amorphous graphite predominates) and contains significantly more sulphur, which is bound to pyrite or pyrrhotite. It is characteristic of the whole area that the positions of graphite in limestones contain more combustible substances and less sulphur than the positions in graphitic schists and phyllites. The largest deposit in Moravia was considered to be Velké Tresné deposit, which is practically exhausted today. It is located in the Olešnice group of the Svratka dome. In the Silesian Block, the most important deposit was Velké Vrbno-Konstantin, which forms part of the graphite zone on the western perimeter of the Velké Vrbno dome, and from the second half of 2003 to 2008 it remained the only mined deposit in the Czech Republic. In the vicinity of Branná and Velké Vrbno, several other small deposits and sources of mostly amorphous graphite are registered.

In most cases, the same applies to graphite deposits in the Czech Republic as to fluorspar and barite: underground mining is economically unprofitable and has gradually declined. For a long time, the Czech Republic had been one of the world's leading producers of graphite, but mainly due to the growing pressure of cheaper and better quality, especially Chinese graphite, mining was ended. In southern Bohemia, the majority of the raw material is recoverable by deep mining and a smaller part also by surface mining. The last deposits of crystalline graphite in southern Bohemia that were mined underground were closed in the second half of 2003. In northern Moravia, underground mining also originally predominated, but part of the raw material can also be recovered on the surface, and the last quarry of amorphous graphite Velké Vrbno – Konstantin ended its mining activities in 2008. The raw graphite material was flotation-processed in treatment plants in Netolice, where flotation concentrates with a content of 75 to 90% of graphite were produced, and also in Malé Vrbno, where concentrates with a content of 50 to 70% of graphite were produced. Some flotation concentrates were chemically refined in Týn nad Vltavou up to 99.9%.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits exhausted deposits and other resources

Registered deposits and other resources are not mined

Amorphous graphite:	Crystalline graphite:	Mixed (from amorphous to crystalline) graphite:
1 Velké Vrbno-Konstantin	5 Český Krumlov-Městský vrch	8 Spolí
2 Bližná-Černá v Pošumaví	6 Lazec-Křenov	
3 Český Krumlov-Rybářská ulice	7 Koloděje nad Lužnicí-Hosty	
4 Velké Vrbno-Luční hora 2		

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	8	8	8	8	8
exploited	0	0	0	0	0
Total mineral *reserves, kt [a)]	13,701	13,701	13,701	13,112	13,112
economic explored reserves	2,981	2,981	2,981	2,981	2,981
economic prospected reserves	4,935	4,935	4,935	4,935	4,935
potentially economic reserves	5,785	5,785	5,785	5,785	5,785
Mine production, kt [a)]	0	0	0	0	0

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

[a)] Reserves and mine production are given for crude graphite (graphite "ore"); average graphite contents in the raw material range between 15 and 20% (crystalline grade) and 25–35% (amorphous grade), respectively

Approved prognostic resources P_1, P_2, P_3

Year		2017	2018	2019	2020	2021
P_1,	kt	3,997	3,280	3,280	3,280	3,280
P_2,	kt	5,279	8,895	8,895	8,895	8,895
P_3,	kt	1,505	2,627	2,627	2,627	2,627

5. Foreign trade

2504 – Natural graphite

		2017	2018	2019	2020	2021
Import	t	4,543	5,419	4,182	2,509	2,142
Export	t	2,876	2,851	2,004	2,582	2,450

2504 – Natural graphite

		2017	2018	2019	2020	2021
Average import prices	CZK/t	20,475	21,554	22,985	24,642	30,558
Average export prices	CZK/t	33,072	31,165	28,710	28,404	27,286

3801 – Artificial graphite; colloidal or semi-colloidal graphite; preparations based on graphite

		2017	2018	2019	2020	2021
Import	t	2,517	3,289	4,032	2,780	2,302
Export	t	1,399	2,306	8,068	4,961	1,113

3801 – Artificial graphite; colloidal or semi-colloidal graphite; preparations based on graphite

		2017	2018	2019	2020	2021
Average import prices	CZK/t	50,338	44,238	57,246	59,594	57,840
Average export prices	CZK/t	45,692	33,548	37,506	46,496	34,269

6903 – Other refractory ceramic goods (for example, retorts, crucibles, muffles, nozzles, plugs, supports, cupels, tubes, pipes, sheaths and rods)

		2017	2018	2019	2020	2021
Import	t	12,939	5,663	6,714	4,068	6,181
Export	t	24,340	25,679	25,193	21,258	27,142

6903 – Other refractory ceramic goods (for example, retorts, crucibles, muffles, nozzles, plugs, supports, cupels, tubes, pipes, sheaths and rods)

		2017	2018	2019	2020	2021
Average import prices	CZK/t	44,210	104,970	80,763	114,159	100,402
Average export prices	CZK/t	109,159	112,530	114,246	127,488	119,886

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

World graphite production has been gradually increasing again since 2009, when it reached its last low. Between 2013 and 2016, world production was very stable and ranged between 1,100 and 1,200 kt, with world graphite mining falling to around 900 kt in 2017, in 2018–2019 world mining increased again to between 950 and 1,150 kt and in 2020 it decreased to 950 kt.

	2017	2018	2019	2020	2021^e
World mine production of graphite (according to MCS), kt	897	1,120	1,100	966	1,000
World mine production of graphite (according to WBD), kt	896	1,041	1,133	940	N

e – preliminary values

Main producers according to MCS

Country	2021^e	
	kt	%
China	820	79
Brazil	68	7
Mozambique	30	3
Russia	27	3
Madagascar	22	2
Ukraine	17	2
Norway	13	1
Korea, North	8.7	1
Canada	8.6	1
India	6.5	1
Vietnam	5.4	1
Sri Lanka	4.3	0.4
Mexico	3.5	0.3
World	**1,000**	**100**

e – preliminary values

Prices of traded commodities (USD/t)

Commodity/year	2017	2018	2019	2020	2021
Prices of imports to the USA in foreign ports – flake, USD/t, according to MCS	1,390	1,520	1,350	1,540	1,600
Prices of imports to the USA in foreign ports – lump and chip (Sri Lanka), USD/t, according to MCS	1,900	1,890	2,380	2,940	2,700
Prices of imports to the USA in foreign ports – amorphous, USD/t, according to MCS	451	319	498	687	630

METALLIC ORES

Ores are, in the Czech terminology exclusively, metallic mineral raw materials from which metals can be industrially produced. Deposits of Mn, Cu, polymetallic (Pb, Zn, Ag), Sn, W, Li, Au and Ge ores were registered in the Register as at the 1st January 2022 in the Czech Republic. Geological reserves of ores were, with a few exceptions, potentially economic; more significant amounts of economic reserves were reported only for gold-bearing ores.

Ore mining in the Czech Republic has a very old tradition. The oldest archaeological evidence of panning for gold dates from the 9th century BC. In the Middle Ages, Bohemia was a centre of European gold, silver and tin mining, the resources of which were almost exhausted by long-term mining activities. With a few exceptions (e.g. the Au-W ore deposit in Kašperské Hory), there are only poor ores in the Czech Republic. Mining experienced its last great boom during the Cold War after 1948, when ore deposits were mined with significant economic losses in order to ensure independence from the import of raw materials from Western countries. The level of ore mining and its development has long been influenced by the "limit costs of metals" declared by the central authorities, through which ore mining was subsidised from 1965 to 1988. The amount of reserves, both geological and, above all, industrial, corresponded to this. In connection with the changes that took place in the Czech Republic in 1989, the government adopted in 1990 the concept of a phase-out in ore mining and processing. The basis of this concept was a gradual but radical reduction of subsidies for mining and processing of ores so that since 1993 the subsidies have not been provided at all. As a result of the termination of subsidies, the mining of ore deposits was gradually phased out before 1993. First, in 1990, mining ended on Cu ore deposits in Zlaté Hory (Zlaté Hory-Hornické skály and Zlaté Hory-jih deposits in mining lease Zlaté hory – východ). Cu metal was then obtained until 1993 from deposits of polymetallic ores. At the beginning of 1991, the mining of Sn-W ores at the Krásno deposit (mining lease Krásno) ended. In 1991, a miniature deposit of Scheelite W ores was mined as part of experimental mining in Nekvasovy-Chlumy. Mining at the Sn-W-Li ore deposit Cínovec-jih (mining lease Cínovec) ended a year earlier. Mining of Fe ores in the Czech Republic ended in 1992, when the Přísečnice magnetite deposit was closed. The mining of Au ores and Sb also ended in 1992 with the closure of the Krásná Hora deposit. In the first quarter of 1994, the mining of polymetallic and Au ores in Zlaté Hory (Zlaté Hory-západ deposit, mining lease Zlaté Hory I – západ) was definitively terminated, and this was the last ore deposit in the Czech Republic (if we do not consider U ores, which are classified as energy minerals). The reserves of ore deposits were subsequently gradually reassessed according to new conditions of usability and, the formerly economic ores, were, with some exceptions (e.g. some Au ore deposits), reclassified as potentially economic and in some cases even removed from the Register completely (all Fe, Ni, Sb ores, most polymetallic ores, Cu, Sn, W and Ge ores).

Cobalt

1. Characteristics and use

Average Co content (and its extent) in the earth's crust (ppm)

25 (8–237) Co

Industrially important minerals

Cobaltite CoAsS (35% Co), smaltite $CoAs_3$ (24% Co), carrollite $Cu(Co,Ni)_2S_4$ (29% Co), asbolane $Mn(O,OH)_2.(Co,Ni,Ca)_x(OH)_2.nH_2O$ (32% Co)

Industrially important deposit types

Cobalt ores are generally found as an accompanying raw material in copper and nickel deposits. Especially in the copper deposits of the Copper Belt area (Democratic Republic of the Congo, i.e. Congo (Kinshasa) and Zambia).

Reserves

2021		
Country	t	% world
Congo (Kinshasa)	3,500,000	49,3
Australia	1,400,000	19,7
Indonesia	600,000	8,5
Cuba	500,000	7,0
Philippines	260,000	3,7
Russia	250,000	3,5
Canada	220,000	3,1
Madagascar	100,000	1,4
China	80,000	1.1
USA	69,000	1.0
Papua New Guinea	47,000	0.7
Morocco	13,000	0.2
World	**7,100,000**	**100.0**

Source: MCS 2022

2021			
Country	t	% world	% EU
EU	192,056	100.0	2.7
Poland	157,000	81.7	2.2
Finland	35,056	18.3	0.5

Source: European Minerals Yearbook – version 2022

Uses

Rechargeable battery electrodes, superalloys for the production of parts for gas turbine engines, car airbags, catalysts for the oil and chemical industry, sintered carbides (hard metals) and diamond tools, corrosion and wear resistant alloys, desiccants for paints, coats and inks, dyes and pigments, ground coatings for enamelled porcelain paints, high speed steels, magnetic recording media, magnets, and steel radial tires.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved sources of cobalt in the total amount of 8,035 t Co, mainly in the Staré Ransko locality.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2605 – Cobalt ores and concentrates

		2017	2018	2019	2020	2021
Import	kg	400	500	476	1,348	2,300
Export	kg	0	0	0	0	0

2605 – Cobalt ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	1,605	1,570	1,637	492	250
Average export prices	CZK/kg	–	–	–	–	–

8105 – Cobalt mattes and other intermediate products of cobalt metallurgy; cobalt and articles thereof, including waste and scrap

		2017	2018	2019	2020	2021
Import	t	139	90	117	80	95
Export	t	50	49	53	33	71

8105 – Cobalt mattes and other intermediate products of cobalt metallurgy; cobalt and articles thereof, including waste and scrap

		2017	2018	2019	2020	2021
Average import prices	CZK/t	1,177,537	1,789,808	1,406 ,61	1,500,534	1,482,289
Average export prices	CZK/t	921,580	1,163,094	1,317,312	1,151,138	1,077,027

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

Statistical data on world cobalt production:

	2017	2018	2019	2020	2021^{e}
Mine production of cobalt (according to CI), t	116,937	124,344	153,700	145,000	144,000
Mine production of cobalt (according to MCS), t	120,000	148,000	144,000	142,000	170,000
Mine production of cobalt (according to WBD), t	138,692	158,317	124,968	129,110	N

e – preliminary values
(CI – Cobalt Institute)

Main producers according to MCS

Country	2021[e]	
	t	%
Congo (Kinshasa)	120,000	85.7
Russia	7,600	5.4
Australia	5,600	4.0
Philippines	4,500	3.2
Canada	4,300	3.1
Cuba	3,900	2.8
Papua New Guinea	3,000	2.1
Madagascar	2,500	1.8
Morocco	2,300	1.6
China	2,200	1.6
Indonesia	2,100	1.5
USA	700	0.5
World	**140,000**	**100.0**

e – preliminary values

The world's largest cobalt miners / producers according to INN.com

1. Glencore
2. Euroasian Resources Group
3. China Molybdenum
4. Gecamines
5. Zhejiang Huayou Cobalt

Prices of traded commodities

Annual prices according to yearbooks DERA, MCS

Commodity/year	2017	2018	2019	2020	2021
99.8% Co free market, in warehouse, Rotterdam (USD/kg)(DERA)	54.65*)	81.16	39.52	38.08	57.68
Co cathodes, US spot market, annual average, USD/lb (MCS)	26.97	37.43	16.95	15.70	23.00
99.8% Co, LME, in warehouse, cash (USD/t) (DERA)	72,361	72,621	32,796	31,331	51,118

**) Engineering&Mining Journal: 12 monthly quotations average*

Copper

1. Characteristics and use

Average Cu content (and its extent) in the earth's crust (ppm)

68 (10–100) Cu

Industrially important minerals

Chalcopyrite $CuFeS_2$ (34% Cu), covellite CuS (66% Cu), chalcocite Cu_2S (80% Cu), bornite Cu_5FeS_4 (63% Cu), enargite Cu_3AsS_4 (47% Cu), tetrahedrite $Cu_{12}Sb_4S_{13}$ (max. 45% Cu)

Industrially important deposit types

1. Porphyry (with Mo): Chuquicamata (Chile), Bingham (USA), Recsk (Hungary), Dexing (China)
2. Pyrite polymetallic: Iberian pyrite belt (Spain – Portugal), Outokumpu district (Finland), Baiyinchang district (China)
3. Stratiform: Jezkazgan (Kazakhstan), White Pine District (USA), Copper Belt Region (Democratic Republic of the Congo – Zambia), Polkowice-Sieroszowice district (Poland), Liwu (China)
4. Magmatogenic: Norilsk (Russia), Sudbury (Canada), Jinchuan (China)
5. Magmatic-hydrothermal: Olympic Dam (Australia)

Reserves

2021		
Country	mill t	% world
Chile	200	23.0
Peru	93	10.7
Australia	77	8.9
Russia	62	7.1
Mexico	53	6.1
USA	48	5.5
Poland	31	3.6
China	31	3.6
Zambia	26	3.0
Kazakhstan	24	2.8
(Kinshasa)	21	2.4
Canada	20	2.3
Germany	10	1.1
World	**870**	**100.0**

Source: MCS 2022

2021			
Country	mill t	% world	% EU
EU	125	14.35	100.00
Romania	98	11.26	78.50
Poland*	22	2.53	17.62
Sweden	2	0.19	1.32
Spain	1	0.13	0.89
Finland	1	0.11	0.79
Portugal	1	0.10	0.71
Makedonie	0.2	0.02	0.17

** Bilans zasobów złóż kopalin w Polsce 2021*

Source: European Minerals Yearbook – version 2021

Uses

Transmission and production of electricity, building wiring, telecommunications and the manufacture of electrical and electronic products account for about three quarters of total copper use. The construction industry is a massive market, followed by electronics and electronic products, transport, industrial machinery, consumer and general products.

Classification as critical raw materials for the European Union:

2011 – no, 2014 – no, 2017 – no, 2020 – no

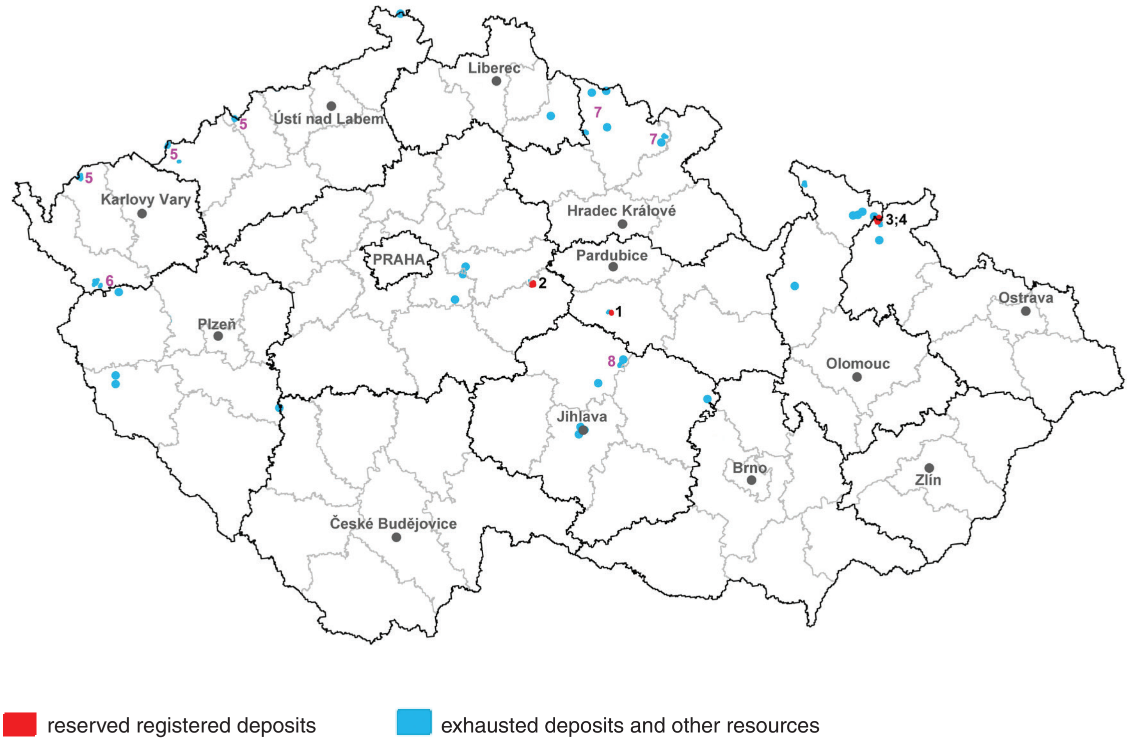
2. Mineral resources of the Czech Republic

There are no economically usable deposits of Cu ores in the Czech Republic. Cu ores of various genetic types have been present and used in the past.

- Volcanogenic-sedimentary deposits of the pyrite formation with the most significant occurrence in the Zlaté hory ore district were mined the most. The ore mineralisation, paragenetically associated with the initial spilite-keratophyre volcanism, is located in the volcanic-sedimentary complex of the Vrbno layers of Devonian age. Individual types of ores, monometallic Cu, complex Cu-Pb-Zn with Au and polymetallic Pb-Zn, are spatially separated and create a certain zonality. Monometallic ores consisted of chalcopyrite, with a variable admixture of pyrite or pyrrhotite with a metal content of 0.4–0.7% Cu. They were mined in the Zlaté Hory-jih and Zlaté Hory-Hornické skály deposits. The mining of these ores was terminated at the Zlaté Hory deposit in 1990. A total of 5,808 kt of ore containing 34,741 t of copper was mined in 1965–1990.
- The stratiform layers of monometallic Cu ores (chalcopyrite) in the epizonally metamorphosed volcanogenic-sedimentary complex are explored at the former deposit Tisová u Kraslic. Mining of ores with a content of up to about 1% Cu was stopped in 1973 and in the 1980s a preliminary exploration was carried out on the deposit, the results of which, however, were no longer used and the deposit (mine) was transferred to wet conservation.
- Less significant occurrences of Cu or Cu-Zn-Pb ores of the stratiform type of pyrite formation are known from many localities in the Bohemian Massif (Staré Ransko, Křižanovice, Svržno).
- Hydrothermal (vein) deposits of Cu ores (Rybnice, Rožany) and sedimentary Cu ores (Giant Mts. Foothils (Podkrkonoší)) were of only historical significance. A very poor former Horní Vernéřovice-Jívka deposit was mined here in 1958–1965.

Mining of Cu ores in the Czech Republic was stopped in 1990. In connection with the ongoing reassessment (rebalancing) of polymetallic and copper ores, a large part of Cu deposits and reserves was gradually removed from the Balance in 1990–2004.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined

Reserved registered deposits:

1	Křižanovice	3	Zlaté Hory-Hornické Skály
2	Kutná Hora	4	Zlaté Hory-východ

Exhausted deposits and other resources:

5	in Krušné hory Mts. (Erzgebirge Mts.) and Tisová	7	in Krkonoše Mts. Piedmont Basin and Intrasudetic Basin
6	Tři Sekery and surroundings	8	Staré Ransko

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number [a)]	4	4	4	4	4
exploited	0	0	0	0	0
Total mineral *reserves, kt Cu	51	51	51	51	51
economic explored reserves	0	0	0	0	0
economic prospected reserves	0	0	0	0	0
potentially economic reserves	51	51	51	51	51
Mine production, kt Cu	0	0	0	0	0

** See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

[a)] *deposits with registered Cu content*

5. Foreign trade

2603 – Copper ores and concentrates

		2017	2018	2019	2020	2021
Import	t	1	0.014	0.013	0	1
Export	t	24	0	0	0	0

2603 – Copper ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/t	73,059	357,143	384,615	–	76,000
Average export prices	CZK/t	140,726	–	–	–	–

7402 – Unrefined copper

		2017	2018	2019	2020	2021
Import	t	62	25	181	114	168
Export	t	0,002	0	0.006	242	112

7402 – Unrefined copper

		2017	2018	2019	2020	2021
Average import prices	CZK/t	218,124	308,624	94,232	131,927	149,047
Average export prices	CZK/t	500,000	–	333,333	110,809	80,814

7403 – Refined copper and copper alloys

		2017	2018	2019	2020	2021
Import	t	7,340	7,879	7,350	6,541	7,133
Export	t	412	2,329	1,447	1,550	2,005

7403 – Refined copper and copper alloys

		2017	2018	2019	2020	2021
Average import prices	CZK/t	97,431	94,769	92,006	84,585	102,693
Average export prices	CZK/t	129,739	127,384	133,823	138,954	139,621

7404 – Copper waste and scrap

		2017	2018	2019	2020	2021
Import	t	7,733	7,688	5,844	7,499	7,134
Export	t	60,360	61,158	57,088	57,719	66,761

7404 – Copper waste and scrap

		2017	2018	2019	2020	2021
Average import prices	CZK/t	103,826	100,304	82,131	85,355	102,694
Average export prices	CZK/t	96,483	103,640	97,739	97,979	136,214

740311 – Copper cathodes and sections of cathodes unwrought

		2017	2018	2019	2020	2021
Import	t	1,228	1,001	1,474	1,429	1,853
Export	t	122	25	19	3	7

740311 – Copper cathodes and sections of cathodes unwrought

		2017	2018	2019	2020	2021
Average import prices	CZK/t	148,137	141,402	138,457	140,871	200,613
Average export prices	CZK/t	152,367	147,302	156,819	156,471	225,445

740321 – Copper-zinc base alloys, unwrought

		2017	2018	2019	2020	2021
Import	t	5,554	6,074	5,204	4,528	4,599
Export	t	1,664	2,080	1,260	1,396	1,748

740321 – Copper-zinc base alloys, unwrought

		2017	2018	2019	2020	2021
Average import prices	CZK/t	74,332	72,457	64,822	53,147	45,224
Average export prices	CZK/t	140,029	130,285	141,36	144,216	144,026

740322 – Copper-tin base alloys, unwrought

		2017	2018	2019	2020	2021
Import	t	208	186	126	81	84
Export	t	137	180	129	147	245

740322 – Copper-tin base alloys, unwrought

		2017	2018	2019	2020	2021
Average import prices	CZK/t	187,028	225,240	243,627	240,841	359,526
Average export prices	CZK/t	90,418	102,776	76,484	88,881	104,318

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

World production of primary copper has been rising in recent years:

	2017	2018	2019	2020	2021
World mine production of copper (according to COCHILCO), kt	20,176	20,386	20,742	20,660	N
World mine production of copper (according to MCS), kt	20,000	20,400	20,400	20,600	21,000
World mine production of copper (according to WBD), kt	20,084	20,702	20,650	20,788	N

Main producers according to MCS

Country	2021	
	kt	%
Chile	5,600	26,7
Peru	2,200	10,5
China	1,800	8,6
Congo (Kinshasa)	1,800	8,6
USA	1,200	5,7
Australia	900	4,3
Zambia	830	4,0
Russia	820	3,9
Indonesia	810	3,9
Mexico	720	3,4
Canada	590	2,8
Kazachstan	520	2,5
Poland	390	1,9
other	2,800	13,3
World	**21,000**	**100,0**

Main producers to COCHILCO*

Country	2021	
	kt	%
Chile	5,625	26,3
Peru	2,299	10,8
Congo (Kinshasa)	1,878	8,8
China	1,741	8,2
USA	1,228	5,8
Zambia	881	4,1
Russia	881	4,1
Australia	818	3,8
Kazachstan	741	3,5
Mexico	734	3,4
World	**21,354**	**100,0**

* *COCHILCO (Comisión Chilena del Cobre, Chilean state agency for copper)*

Prices of traded commodities

According to the German yearbooks DERA, the Mineral Commodity Summaries (MCS), World Bank (WB), world copper prices (USD/t, if not defined otherwise) developed as follows:

Commodity/year	2017	2018	2019	2020	2021
Electrolytic Cu, grade A, min. 99.9 %, LME, in warehouse, cash (according to DERA)	6,147.17*	6,524.80	6,004.40	6,167.90	9,311.89
Electrolytic Cu, grade A, min. 99.9935%, contractual price (according to WB)	6,170.00	6,530.00	6,010.00	6,174.00	9,317.00
Copper, grade A, LME, annual average, USc/lb (according to MCS)	279.50	296.00	272.40	279.80	420.00

** Engineering & Mining Journal: 12 monthly quotations average*

The price range according to MB includes the lowest and highest monthly price quotes for a given year.

Germanium

1. Characteristics and use

Average Ge content (and its extent) in the earth's crust (ppm)

1.5 Ge

Industrially important minerals

Separate Ge minerals are very rare (e.g. germanite $Cu_{13}Fe_2Ge_2S_{16}$), there are about 15 of them. Ge usually forms an isomorphic admixture of more than 70 minerals. Germanium-bearing minerals are mainly minerals Si, Sn, Pb, Zn, Cu, As, Ga, half silicates and especially sulphides. During weathering, sedimentation and sorption, there is a relatively large concentration of Ge in brown and bituminous coal.

Industrially important deposit types

1. Coal: coking coal of the Donbass and Lviv-Volyn basins (Ukraine);
2. Pb-Zn-Cu sulphide ores: Red Dog (Canada), Middle Tennessee Zinc Mining Complex (USA), Tsumeb (Namibia)
3. Oxide ores of Fe: Kremenchug Iron Ore District (Ukraine)

Reserves

Data on the recoverable Ge content in Zn ores are not available. Source: MCS 2021.
The EU does not have Ge reserves. Source: European Minerals Yearbook – version 2021.

Uses

Electronics, solar panels, optical fibres, infrared optics, polymerisation catalysts, chemotherapy, metallurgy.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes

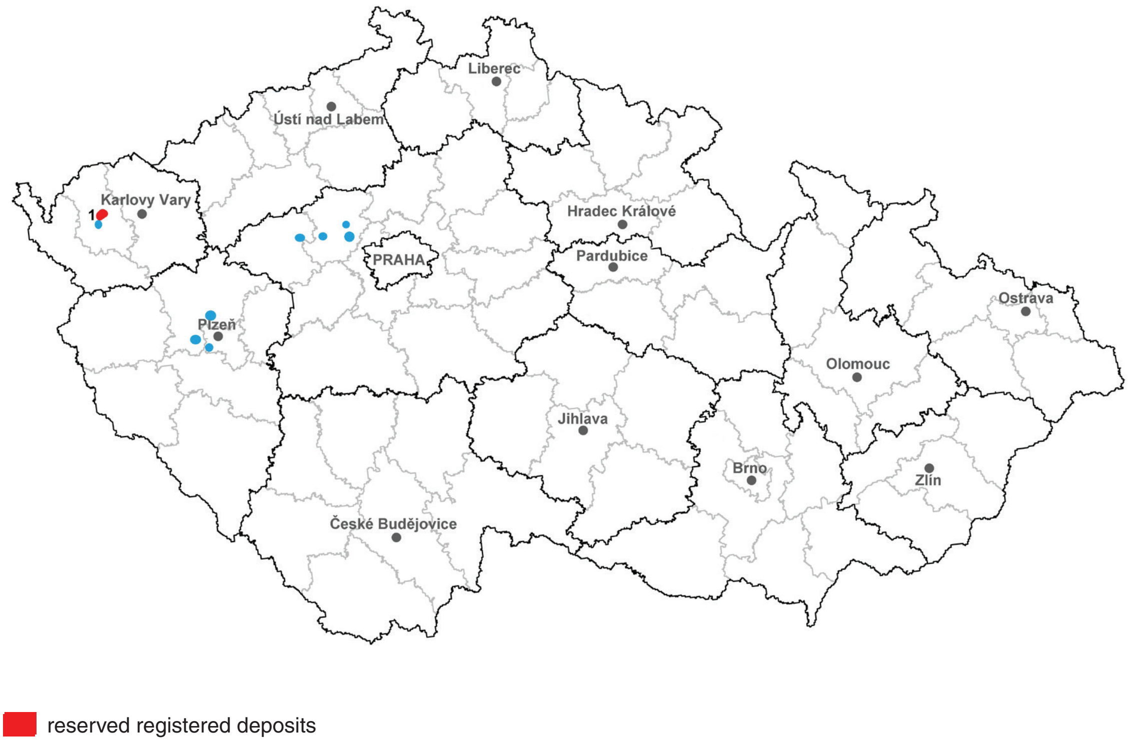
2. Mineral resources of the Czech Republic

The Czech Republic has 1,248 t of unapproved Ge resources bound to brown and bituminous coal deposits.

Germanium and GeO_2 were produced in the Czech Republic at the Lachema chemical plant, J. Fučík's plant, in Kaznějov in 1955–1980. Industrial production from domestic sources was based (according to data from the former Institute for Mineral Resources (ÚNS – Ústav pro nerostné suroviny) in Kutná Hora) on the combustion of germanium-bearing coal in suitable boilers of power plants with subsequent separation of germanium-bearing fly ash (usually containing 0.1–0.3% Ge) and flue gases in dry electrostatic precipitators. In the years 1955–1971 by burning bituminous coal from the Pilsen and Radnice and Kladno-Rakovník basins (with contents of 14–38 ppm Ge). With the closure of mines mining these coals, bituminous coal ash in the production of Ge was replaced after 1966 by brown coal from the combustion of coal mined at the Jiří quarry in the Sokolov Basin (which contained 40–150 ppm Ge). However, in 1972, the production of Ge from fly ash was completely stopped; it reached its peak in 1966 with a quantity of 773 kg.

In the years 1960–1980, a total of 54 t Ge and 4 t GeO_2 were produced in Lachema Kaznějov. Most of this production came from imported GeO_2 (44.7% of total production) and Ge (25.8% of total production) and returnable waste (22.7% of total production). Domestic fly ash accounted for only 3.7 tonnes produced in 1961–1971 (6.8% of total production). The production capacity of Kaznějov's Lachema never reached the planned 10 t of Ge per year, however, in the years 1965–1975 the territory of the Czech Republic (within Czechoslovakia) produced about 5–10% of world's Ge per year.

3. Registered deposits and other resources of the Czech Republic



The registered deposit is not exploited.

1 Lomnice u Sokolov

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	1	1	1	1	1
exploited	0	0	0	0	0
Total * reserves, t Ge	473	473	473	473	473
economic explored reserves	0	0	0	0	0
economic prospected reserves	0	0	0	0	0
potentially economic reserves	473	473	473	473	473
Mine production, t Ge	0	0	0	0	0

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic and its evolutional comparison with international classifications** of this yearbook*

5. Foreign trade

81129295 – Unwrought germanium, germanium powders; excluding waste and scrap

		2017	2018	2019	2020	2021
Import	kg	2	4	4	2	5
Export	kg	1	1	0	0	0

81129295 – Unwrought germanium, germanium powders; excluding waste and scrap

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	21,500	51,500	73,500	51,000	34,800
Average export prices	CZK/kg	90,000	90,000	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

World germanium production was as follows in recent years:

	2017	2018	2019	2020	2021^e
World germanium production (according to MCS), t	106	130	131	140	140
World germanium production (according to WBD), t	98	106	95	96	N

e – preliminary values

Main producers according to MCS

Country	2021^e	
	t	%
China	95	73.1
Russia	5	3.8
USA	40	30.8
World	**130**	**100.0**

e – preliminary values

Prices of traded commodities

Price data are based on the US Mineral Commodity Summary (MCS)

	2017	2018	2019	2020	2021
GeO_2, yearly average, European market, USD/kg, MCS	731	1,084	913	724	770
Ge metal, annual average, European market, MCS	1,082	1,543	1,236	1,046	1,200

Gold

1. Characteristics and use

Average Au content (and its extent) in the earth's crust (ppm)

0.004 (0.001–0.005) Au

Industrially important minerals

Native gold Au (70 – 100% Au, usually with Ag, Cu, Hg, Pd), sylvanite (Au, Ag)Te_4 (25% Au), calaverite $AuTe_2$ (42% Au). Gold occurs as a pure metal, a natural alloy with silver (electrum) or with other metals, possibly in the form of tellurides and also selenides. It is commonly found in sulphides of antimony, arsenic, copper, iron and silver; during their processing, gold is obtained as a by-product.

Reserves

2021		
Country	**t**	**% world**
Australia	11,000	20.4
Russia	6,800	12.6
USA	3,000	5.6
Peru	2,000	3.7
South Africa	5,000	9.3
Indonesia	2,600	4.8
Brazil	2,400	4.4
Canada	2,200	4.1
China	2,000	3.7
Uzbekistan	1,800	3.3
Argentina	1,600	3.0
Mexico	1,400	2.6
Papua New Guinea	1,100	2.0
Ghana	1,000	1.9
Kazakhstan	1,000	1.9
Mali	9,200	17.0
World	**54,000**	**100.0**

Source: European Minerals Yearbook – version 2021

2021			
Country	**t**	**% world**	**% EU**
EU	1 064	2.0	100.0
Greece	527	1.0	49.5
Finland	222	0.4	20.9
Sweden	136	0.3	12.8
Czech Republic	78	0.15	7.3
Slovakia	64	0.12	6.0
Spain	37	0.07	3.5

Source: European Minerals Yearbook – version 2021

Industrially important deposit types

1. Plutogenic (including Cu-Mo deposits with Au in porphyries, skarn, Carlin type): Panguna (Papua New Guinea), Ok Tedi (Papua New Guinea), Bigham (USA), Hemlo (Canada), Southern Cross (Australia) area, Southern Cross (Australia), Muruntau (Uzbekistan), Carlin (USA), Nickel Plate (Canada), Choldon (China), Darasunskoye (Russia), Talatuyskoye (Russia), Kolar (India)
2. Volcanic: Lihir (Papua New Guinea), the Golden Quadrangle (Golden Quadrilateral; Apuseni District) area in the Apuseni Mountains – including the Roşia Montană deposit (Romania), the Silverton-Telluride ore field (USA), the Balayskoye-Tasseyevkoje ore field (Russia), the Baymak district (Russia)
3. Metamorphogenic: Sukhoi Log (Russia), Soviet Union (Russia), Duet-Brindakitsky Ore Knot (Russia), Bou Azzer (Morocco), Bendigo (Australia), Ballarat (Australia), Homestake (USA), Juno (USA), Morro Velho (Brazil)
4. Alluvial: Witwatersrand (South Africa), Yeniseiy Kriyaz (Russia), Lensky and Aldansky (Russia), Nom (USA)

Uses

Gold is used worldwide for the production of jewellery and as a thesauration metal, then in the electrical industry, for the mintage of medals and coins, for the production of dental protheses, special alloys for the aerospace (especially military) industry, for the production of infrared reflectors and more. The quality (purity) of gold is given in carats or parts of 1,000 (pure gold 24 k = 1 000, 10 k = 10/24 = 41.7 % = 417/1 000).

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

Gold deposits are currently, together with lithium ores, the only ore deposits in the Czech Republic on which significant amounts of economic reserves are reported. The tradition of using primary and secondary gold deposits in the Bohemian Massif dates back almost three millennia. In the Middle Ages, the Czech lands were ranked among the most important gold producers in Europe.

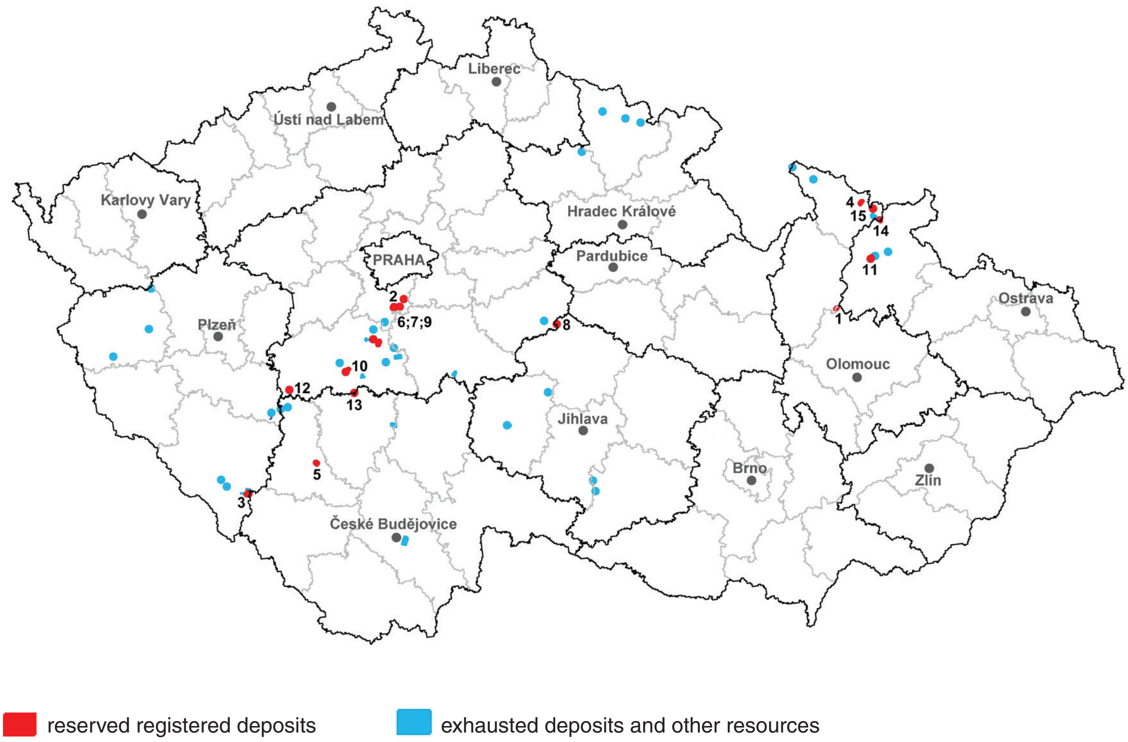
- A substantial part of Au ore mineralisation is bound to regionally metamorphosed volcanic-sedimentary complexes, in places penetrated by Variscan granitoids. In the Central Bohemian region the Jílové zone with a predominance of Au-quartz mineralisation (deposits Jílové, Mokrsko, Čelina, etc.) represents such a complex of Proterozoic age. In the area of the Jeseníky Mountains, this is a Devonian volcanism with Au ore mineralisation associated with pyrite polymetallic deposits of the stratiform type (Zlaté Hory-západ). Gold ore mining was terminated in 1994 with the closure of the Zlaté Hory-západ deposit. A total of 1,524 kg of Au was mined at this deposit in 1990–1994. Of the explored deposits, the Mokrsko deposit shows substantial reserves of Au ores, namely 98 t of Au in ores minable by quarrying with an average content of free balance reserves of 1.9 g/t Au and another more than 20 t of deep-extractable Au. Another 12.5 t of deeply recoverable Au reserves with contents of 1.6 g Au/t in ore are registered at the nearby Prostřední Lhota-Čelina deposit. Thus, there is more than 131 t Au in the entire Psí hory district (Čelina, Mokrsko).

The Vacíkov deposit SW of Příbram is similar; there is over 33 t Au in ores with Au contents of 1.1 g/t, also minable by quarrying.

- Occurrences of Au-quartz vein and stratiform ore mineralisation often with scheelite (Kašperské Hory) and Au-quartz veins and veins with increased Ag content (Roudný) are known in the Moldanubian crystalline complex. The partly unexplored Kašperské Hory deposit records 55 t of Au with an average content of 4.7 g Au/t of gold in off-balance reserves. Together with the adjacent prognostic resources, a total of 115 t Au with an average content of 5.5 g Au/t is reported on the deposit.
- Alluvial gold accumulations are spatially and genetically associated with the areas of primary deposits. Paleo-placers of Permocarbon age are found in western Bohemia (Křivce) as well as in the Krkonoše Mountains and Intra-Sudetic basins. The most extensive in terms of area are the Quaternary placers, known mainly from the foothills of the Šumava Mountains, northern Moravia and Silesia. Remains of panning that are visible to this day testify to the intensive use of placers from the Celtic times.

Since the end of mining at the Sb-Au deposit Krásná Hora in 1992 and the polymetallic deposit Zlaté Hory-západ in 1994, gold has not been mined in the Czech Republic. The use of Au ores in deposits is hindered by unresolved conflicts of interest with environmental protection and, from a global perspective unique ban on cyanidation in mining in the Czech Republic. In addition, a government resolution from 1999 stated that gold mining is undesirable in the Czech Republic. Subsequent governments extended the ban to include also the exploration of Au ores.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined.

1 Břevenec
2 Jílové u Prahy
3 Kašperské Hory
4 Mikulovice u Jeseníka
5 Modlešovice
6 Mokrsko
7 Mokrsko-východ
8 Podmoky
9 Prostřední Lhota-Čelina
10 Smolotely-Horní Líšnice
11 Suchá Rudná-střed
12 Vacíkov
13 Voltýřov
14 Zlaté Hory-východ
15 Zlaté Hory-Zlatý potok

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	15	15	15	15	15
exploited	0	0	0	0	0
Total mineral *reserves, kg Au	238,900	238,900	238,900	238,900	238,900
economic explored reserves	48,740	48,740	48,740	48,740	48,740
economic prospected reserves	28,644	28,644	28,644	28,644	28,644
potentially economic reserves	161,516	161,516	161,516	161,516	161,516
Mine production, kg Au	0	0	0	0	0

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Au metal in ores

Year		2017	2018	2019	2020	2021
P_1,	kg	60,221	60,221	60,221	60,221	60,221
P_2,	kg	65,846	65,846	65,846	65,846	65,846
P_3		–	–	–	–	–

Au ore

Year		2017	2018	2019	2020	2021
P_1,	kt	16,726	16,726	16,726	16,726	16,726
P_2,	kt	27,331	27,331	27,331	27,331	27,331
P_3		–	–	–	–	–

5. Foreign trade

7108 – Gold in unwrought or semi-manufactured form, gold powder

		2017	2018	2019	2020	2021
Import	kg	6,198	6,235	4,790	6,348	9,011
Export	kg	5,089	5,919	6,766	5,417	3,418

7108 – Gold in unwrought or semi-manufactured form, gold powder

		2017	2018	2019	2020	2021
Average import prices	CZK/g	911.5	861.5	952.5	1,189	1,175
Average export prices	CZK/g	554.8	256.7	344.4	380.1	335.3

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

Trend in the world's primary gold production

	2017	2018	2019	2020	2021e
Mine production of gold, t (according to COCHILCO)	3,280	3,288	3,235	3,094	3,062
Mine production of gold, t (according to MCS)	3,230	3,300	3,300	3,030	3,000e
Mine production of gold, t (according to WBD)	3,336	3,385	3,318	3,213	N

e – preliminary values
COCHILCO – Comisión Chilena del Cobre (Chilean state agency for copper)

Main producers according to MCS

Country	2021e	
	t	%
China	370	12.3
Australia	330	11.0
Russia	300	10.0
USA	180	6.0
Canada	170	5.7
Ghana	130	4.3
Mexico	100	3.3
Peru	90	3.0
Indonesia	90	3.0
Kazakhstan	60	2.0
others	1,180	39.3
World	**3,000**	**100.0**

e – preliminary values

Main producers according to COCHILCO

Country	2021	
	t	%
China	329	10,7
Australia	315	10,2
Russia	309	10,0
Canada	187	6,1
USA	187	6,1
Mexico	125	4,1
Ghana	118	3,8
Kazachstan	115	3,7
South Africa	105	3,4
Indonesia	103	3,3
World	**3,075**	**100,0**

Prices of traded commodities

Average annual gold prices in USD/tr oz (1 tr oz (troy ounce) = 31.1035 g) according to the German yearbook DERA, American yearbook MCS and the World Bank's "Pink Sheet" (WB)

Commodity/year	2017	2018	2019	2020	2021
Gold 99.9 %. LME, in warehouse (according to DERA)	1,254*	1,270	1,392	1,767	1,802
Au 99.5% (UK), LME average daily quotation (WB)	1,258	1,269	1,392	1,770	1,800
Au metal, annual price average (MCS)	1,261	1,272	1,395	1,774	1,800

** Engineering&Mining Journal: 12 monthly quotations average*

Iron

1. Characteristics and use

Average Fe content (and its extent) in the earth's crust (%)

5 (3–6.5) Fe

Industrially important minerals

Magnetite $FeO.Fe_2O_3$ (72% Fe), hematite Fe_2O_3 (70% Fe), siderite $FeCO_3$ (48% Fe)

Industrially important deposit types

1. Magmatic-hydrothermal: Kiruna (Sweden), Malmberget (Sweden), El Romeral (Chile)
2. Hydrothermally-metasomatic, with massive siderite: Bakal (Russia), Bilbao (Spain), Erzberg (Austria), Jerissa (Tunisia)
3. Banded iron formation (BIF): Hamersley region (Australia), Minas Gerais (Brazil), Lake Superior region (USA), Krivy Rih (Ukraine), Kursk Magnetic Anomaly region (Russia)

Reserves

2021		
Country	**kt***	**%**
Australia	25,000,000	29.4
Brazil	15,000,000	17.6
Russia	14,000,000	16.5
China	6,900,000	8.1
India	3,400,000	4.0
Ukraine	2,300,000	2.7
Canada	2,300,000	2.7
Iran	1,500,000	1.8
Peru	1,500,000	1.8
USA	1,000,000	1.2
Kazakhstan	900,000	1.1
South Africa	670,000	0.8
Sweden	600,000	0.7
Turkey	38,000	0.01
others	9,500,000	11.2
World	**85,000,000**	**100.0**

** metal content*
Source: MCS 2022

2021			
Country	**kt**	**% world**	**% EU**
EU	635,755	100.0	0.6
Sweden	528,485	83.1	0.5
Romania	57,000	9.0	0.1
Norway	40,530	6.4	0.04
Slovakia	5,740	0.9	0.01
Italy	4,000	0.6	0.004

Source: European Minerals Yearbook – version 2022

Uses
Iron ores are mainly used for the production of pig iron, either directly in untreated form as lump ores or as powdered ores and concentrates lumped by agglomeration or pelletisation. Some modern iron production technologies such as DRI (Direct Reduction of Iron) or COREX® also allow the processing of dust ores and concentrates without prior lumping.

Very small amounts of iron ore are used for non-metallurgical purposes – as weights, in the production of special cement (e.g. for underwater work), ferrites, animal feed, dyes, etc.

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic
There are no economically usable deposits of Fe ores in the Czech Republic. The ores occurring on the territory of the republic are poor, they generally have Fe contents below 40% and in most cases, they are recoverable by underground mining. At present, deposits of much richer ores with Fe contents of around 50% or more are mostly mined in the world. The average Fe contents in iron ores traded on the world market are 60% and more. The availability of higher quality and relatively cheaper iron ore from imports has led to a gradual cessation of iron ore mining in the Czech Republic. Mining of Fe ores in the Czech Republic definitely ended in 1992, when the Přísečnice magnetite deposit was closed. At the same time, the reserves of these ores were gradually removed from the Register as completely uneconomical, and since 2004 no exclusive deposits of Fe ores have been registered in the Czech Republic.

- Sedimentary iron ores are found in the Barrandian. They are Paleozoic ores of marine origin in sediments of Ordovician age. They are mostly in the shape of relatively large lenses. The ores are mainly represented by hematite, siderite and Fe-silicates (leptochlorites). The Fe content reaches an average of 25 to 30%; it is characterised by the oolithic structure of ores and a high content of SiO_2. It was intensively mined in many places (e.g. Nučice, Ejpovice, Mníšek pod Brdy, Zdice, etc.) mainly in the 19th and first half of the 20th century. The final termination of mining of these ores occurred in 1967, when the Ejpovice and Krušná Hora deposits were closed, and during 1997–1999 the remaining reserves of all sedimentary Fe deposits in the Czech Republic were written off and removed from the records of reserved mineral deposits.
- In the Moravian-Silesian Devonian there is a volcanic-sedimentary ore mineralisation of the Lahn-Dill type. Ores containing mainly hematite, magnetite and less Fe-silicates form smaller lenticular bodies, often intensely folded. Magnetite ores had average Fe contents of about 35 to 40% Fe, ores with a predominance of hematite slightly lower (about 30%). Ores were mined in many places (Medlov, Benkov, Králová, Horní Město, etc.). The main development of mining activity was in the 19th century; its final termination came in the mid-1960s. Also, all remaining reserves of Lahn-Dill deposits were written off and removed from the Register in 1997–1999.
- Small magnetite lenses are typical for skarns of the Moldanubicum (Vlastějovice, Županovice, Malešov, Budeč), the Krušné hory formation (Měděněc, Přísečnice, Kovářská), the Krkonoše-Jizera crystalline complex, etc. Fe contents in ores were mostly around 33 to 38%. Mining mostly ended in the 1960s, and in the Přísečnice and Měděnec deposits

in 1992. Residual reserves of these deposits were also removed from the Register by the end of the 1990s.

- Other genetic types of Fe ore mineralisation were mostly of only marginal importance. These were, for example, banded ores of the Sydvaranger type (Sobotín, etc.), hydrothermal ores (Krušné Hory, etc.), stratiform ores (Hraničná, etc.), sedimentary (except Ordovician), weathering, metasomatic, etc.

In the past (peak in the 19th and early 20th centuries), Fe deposits were extensively mined and relatively expensively processed, mainly as a charge for the production of pig iron. This is especially true for the poor and acidic sedimentary ores of the Barrandian, which have been subjected to Krupp-Ren process treatment. Magnetite was used to a large extent (almost exclusively in the 1970s and 1990s) for non-metallurgical purposes such as the production of cement and heavy concrete, as a heavy medium in jigs of coal treatment plants, etc.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2601 – Iron ores and concentrates

		2017	2018	2019	2020	2021
Import	t	5,463,875	6,015,283	5,335,440	4,915,243	6,035,837
Export	t	104,308	6,874	3,343	26	1

2601 – Iron ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/t	2,249	2,008	2,590	2,694	3,882
Average export prices	CZK/t	2,928	2,932	3,742	5,405	–

7201 – Crude iron

		2017	2018	2019	2020	2021
Import	t	58,192	60,738	54,504	47,175	56,918
Export	t	102,680	147,970	45,748	51,827	85,714

7201 – Crude iron

		2017	2018	2019	2020	2021
Average import prices	CZK/t	9,442	9,630	9,545	9,090	13,556
Average export prices	CZK/t	7,830	7,745	8,563	8,535	11,542

7204 – Ferrous waste and scrap, remelted scrap ingots or iron or steel

		2017	2018	2019	2020	2021
Import	t	461,000	469,056	443,433	441,663	509,861
Export	t	2,254,265	2,286,842	2,263,155	2,188,727	2,388,140

7204 – Ferrous waste and scrap, remelted scrap ingots or iron or steel

		2017	2018	2019	2020	2021
Average import prices	CZK/t	6,904	7,135	6,085	5,854	9,338
Average export prices	CZK/t	6,782	7,385	6,600	6,216	10,009

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

World production of iron ore in recent years according to published statistics:

	2017	2018	2019	2020	2021[e]
World mine production of iron ore (according to MCS), mill t	2,430	2,460	2,450	2,470	2,600
World mine production of iron ore (according to WBD), mill t	1,511	1,524	1,552	1,523	N

e – preliminary values

Main producers according to MCS

Country	2021^{e}	
	Mill t	%
Australia	900	34.6
Brazil	380	14.6
China	360	13.8
India	240	9.2
Russia	100	3.8
Ukraine	81	3.1
Canada	68	2.6
South Africa	61	2.3
Iran	50	1.9
USA	46	1.8
Sweden	40	1.5
Mexico	17	0.7
Peru	16	0.6
Turkey	16	0.6
others	90	3.5
World	**2,600**	**100.0**

e – preliminary values

Prices of traded commodities

Average annual prices of iron ore according to MCS yearbooks and World Bank data

Commodity/year		2017	2018	2019	2020	2021
Iron ore, any origin, spot price, (according to the World Bank)	USD/dmt	71.80	69.80	93.80	108.90	161.70
Iron ore, US market, annual average (according to MCS)	USD/t	78.54	93.00	92.94	91.27	94.00
Ukrainian iron ore, yearly average of import prices (according to CZSO)	USD/t	95.85	90.84	114.26	114.38	178.84

Note: dmt – dry metric ton = one tonne of dry ore

Lead

1. Characteristics and use

Average Pb content (and its extent) in the earth's crust (ppm)

16 (1–20) Pb

Industrially important minerals

Galena PbS (87% Pb), boulangerite ($Pb_5Sb_4S_{11}$ (55% Pb), bournonite $CuPbSbS_3$ (43% Pb).

Lead ores are most often part of polymetallic ores formed mainly by sulphides of lead and zinc, sometimes copper, and are accompanied by obtainable contents of silver and gold and a number of trace elements (e.g. In, Cd, Bi, etc.). The main minerals of these ores are galena and sphalerite, usually with pyrite and often with chalcopyrite. There are various, sometimes conflicting views on the genesis of a number of polymetallic ore deposits, as several genetic processes have often been applied to their origin and final form.

Industrially important deposit types

1. Sedimentary exhalative (sediment-bound, submarine-exhalative – "sedex"): Mt.Isa (Australia), Broken Hill (Australia), Gorevskoye (Russia), Xiaotieshan (China), Maqiongxia (China)
2. Stratiform: Olkusz (Poland), Mississippi Valley (USA), Silvermines (Ireland), Mirgalimsay (Kazakhstan), Frankou (China), Siding (China)

Reserves

2021		
Country	**mill t**	**% world**
Australia	37,000	41.1
China	18,000	20.0
Peru	6,400	7.1
Mexico	5,600	6.2
USA	5,000	5.6
Russia	4,000	4.4
India	2,500	2.8
Kazakhstan	2,000	2.2
Bolivia	1,600	1.8
Sweden	1,100	1.2
Turkey	860	1.0
other countries	5,900	6.6
World	**90,000**	**100.0**

Source: MCS 2022

2021			
Country	**mill t**	**% world**	**% EU**
EU	15 160	17.20	100.00
Poland	9 000	10.20	59.40
Italy	4 000	4.50	26.40
Sweden	1 191	1.40	7.90
Portugal	479	0.50	3.20
Ireland	238	0.30	1.60
Spain	222	0.30	1.50
Slovakia	19	0.02	0.10
Finland	11	0.01	0.07

Source: European Minerals Yearbook – version 2022

Uses
Batteries (85%), chemicals (6%), metallurgical products (4%), electrical engineering, electronics

Classification as critical raw materials for the European Union:
2011 – no, 2014 – no, 2017 – no, 2020 – no

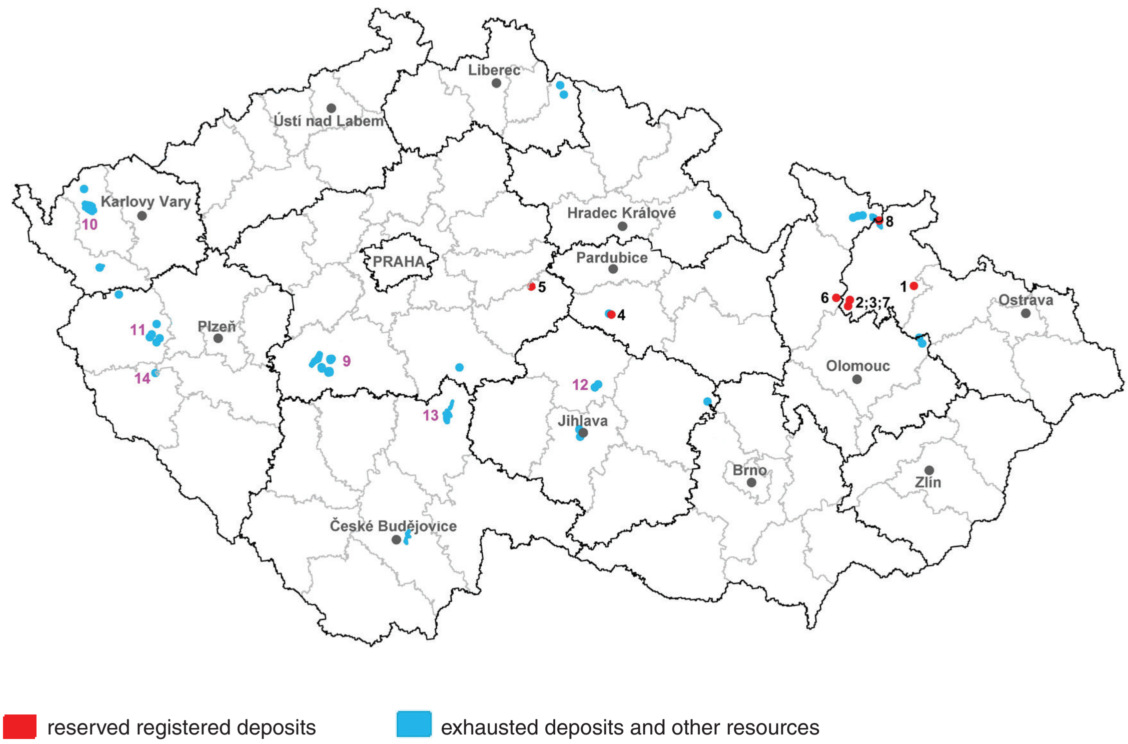
2. Mineral resources of the Czech Republic

The fame of medieval Czech ore mining was largely based on the use of vein hydrothermal deposits of polymetallic ores. Originally it was due to the content of Ag in the ores of these deposits, since the 16th century the mining and processing of lead and later also zinc ores joined in. After the Second World War, in connection with newly carried out exploratory works, volcanic-sedimentary deposits of pyrite formation became important.

- Hydrothermal polymetallic vein ore mineralisation is very abundant in the Bohemian Massif. Alongside the purely historical districts of Oloví, Jihlava, Havlíčkův Brod, the area of the Blanice Graben and others, the Příbram, Stříbro and Kutná Hora districts retained their importance until the 20th century. The main carrier of Pb ore mineralisation was galena (more or less silver-bearing), which could have been as abundant as sphalerite on most Pb-Zn deposits. Most veins had a significantly lower galena content compared to sphalerite only in the Kutná Hora district.
- A slightly different type of hydrothermal ore mineralisation was represented by the former Harrachov deposit with a vein filling consisting of barite, fluorite and galena.
- Stratiform polymetallic ores of the volcanic-sedimentary type, linked to Devonian volcanism, were verified in the 1950s and 1980s in northern Moravia. The subject of mining západ the Horní Město, Horní Benešov deposits and the Zlaté Hory-východ and Zlaté Hory-west deposits in the Zlaté Hory district. Lead contents ranging up to 0.5% were bound to galena, accompanied by sphalerite in the ore strips. The exploitation of a number of other ore objects of similar genesis has not yet begun due to the phase out of ore mining.

The extraction of Pb from polymetallic deposits was terminated in the Czech Republic in 1993 at the last deposit Zlaté Hory-západ. The final product of mining was a complex Pb-Zn concentrate, which was exported because there were no domestic capacities to smelt it. In connection with the ongoing reassessment (rebalancing) of polymetallic ores, a large part of lead deposits and reserves was gradually removed from the Register in 1990–2004.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined

Reserved registered deposits:

1 Horní Benešov
2 Horní Město
3 Horní Město-Šibenice
4 Křižanovice
5 Kutná Hora
6 Oskava
7 Ruda u Rýmařova-sever
8 Zlaté Hory-východ

Exhausted deposits and other resources:

9 Březové Hory + Příbram-Bohutín
10 Oloví
11 Stříbro
12 Havlíčkův Brod (Dlouhá Ves + Bartoušov + Stříbrné Hory)
13 Ratibořské Hory + Stará Vožice
14 Černovice

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number [a)]	8	8	8	8	8
exploited	0	0	0	0	0
Total mineral *reserves, kt Pb	161	161	161	161	161
economic explored reserves	0	0	0	0	0
economic prospected reserves	0	0	0	0	0
potentially economic reserves	161	161	161	161	161
Mine production, kt Pb	0	0	0	0	0

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

[a)] Deposits with registered Pb content

Approved prognostic resources P_1, P_2, P_3
Polymetallic (Pb – Zn ± Cu) ores

Year		2017	2018	2019	2020	2021
P_1,	kt	786	786	786	786	786
P_2,	kt	5,340	5,340	5,340	5,340	5,340
P_3		–	–	–	–	–

5. Foreign trade

2607 – Lead ores and concentrates

		2017	2018	2019	2020	2021
Import	t	0	0	0	0	0
Export	t	0	0	0	0	0

2607 – Lead ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/t	–	–	–	–	–
Average export prices	CZK/t	–	–	–	–	–

7801 – Unwrought lead

		2017	2018	2019	2020	2021
Import	t	146,423	151,534	422,312	164,067	179,418
Export	t	42,833	45,976	40,600	38,209	38,650

7801 – Unwrought lead

		2017	2018	2019	2020	2021
Average import prices	CZK/t	58,898	56,260	17,841	38,113	49,391
Average export prices	CZK/t	59,768	55,275	37,688	46,383	50,378

7802 – Lead waste and scrap

		2017	2018	2019	2020	2021
Import	t	7,232	8,608	10,435	6,946	8,746
Export	t	1,605	904	894	3,522	4,771

7802 – Lead waste and scrap

		2017	2018	2019	2020	2021
Average import prices	CZK/t	45,252	39,857	39,088	36,284	39,461
Average export prices	CZK/t	45,884	32,208	37,688	19,376	24,259

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

World lead production has been slowly declining in recent years. The table shows data from the prestigious International Lead and Zinc Study Group (ILZSG) and data from the Mineral Commodity Summary (MCS) and Welt Bergbau Daten (WBD) yearbooks:

	2017	2018	2019	2020	2021e
World mine production of lead (according to ILZSG*), kt	4,601	4,571	4,678	4,468	4,562
World mine production of lead (according to MCS), kt	4,580	4,560	4,720	4,380	4,300
World mine production of lead (according to WBD), kt	4,650	4,630	4,940	4,746	N

e – preliminary values

** ILZSG – International Lead and Zinc Study Group: An intergovernmental organisation founded in 1959 by the United Nations*

Main producers according to MCS

Country	2021e	
	kt	%
China	2,000	46.5
Australia	500	11.6
USA	300	7.0
Peru	280	6.5
Mexico	270	6.3
Russia	210	4.9
India	210	4.9
Bolivia	90	2.1
Sweden	70	1.6
Turkey	60	1.4
Tajikistan	46	1.1
Kazakhstan	40	0.9
other countries	220	5.1
World	**4,300**	**100.0**

e – preliminary values

Prices of traded commodities

World lead prices (USD/t, if not otherwise stated) according to the German yearbooks DERA, World Bank (WB), and Mineral Commodity Summaries

Commodity/year	2017	2018	2019	2020	2021
99,97 % Pb, LME, cash (according to DERA)	2,360.83*	2,243.35	1,996.90	1,823.70	2,203.83
Rafin. 99,97 %, LME, contractual price (according to WB)	2,315.00	2,240.00	1,997.00	1825.00	2,200.00
Lead, LME, cash (according to MB)	2,006.75–2,596.00	1,867.00–2,683.00	1,768.00–2,347.00	1,570.00–2,120.00	1,610.00–2,400.00
Lead, LME, 3-months contract, (according to MB)	2,021.00–2,592.50	1,882.00–2,675.00	1,774.00–2,341.00	1,595.00–2,140.00	1,640.00–2,435.00
Lead, LME, annual average, spot market, USc/lb (according to MCS)	105.1	101.8	91.0	82.7	99.0

* *Engineering&Mining Journal: 12 montly quotations average*

Manganese

1. Characteristics and use

Average Mn content (and its extent) in the earth's crust (ppm)

1,000 (400–1,600) Mn

Industrially important minerals

Pyrolusite MnO_3 (55–63% Mn), psilomelane $BaMn_3O_{16}$ (45–60% Mn), manganite MnOOH (50–62% Mn), braunite $Mn^{2+}Mn^{3+}{}_6SiO_{12}$ (60–69% Mn), hausmannite $MnMn_2O_4$ (65–72% Mn), rhodochrosite $MnCO_3$ (40–45% Mn)

Industrially important deposit types

1. Hydrothermally-exhalative (volcanic-sedimentary): Molango District (Mexico), deposits of the Transvaal section of western Griqualand (South Africa)
2. Marine-sedimentary: Nikopol (Ukraine), Chiatura (Georgia), Groote Eylandt (Australia), Xiangtan (China), Wafangzi (China)

Huge amounts of Mn are bound to industrially unused deep-sea concretions lying on the ocean floor. It is estimated that these concretions weigh about $2.5.10^{12}$ t. The projected reserves of Mn in concretions (average content of 25% Mn) deposited on the seabed are about 358 million tonnes of metal.

Reserves

2021		
Country	**kt**	**% world**
South Africa	640,000	42,7
Brazil	270,000	18,0
Australia	270,000	18,0
Ukraine, concentrate	140,000	9,3
Gabon	61,000	4,1
China	54,000	3,6
India	34,000	2,3
Ghana	13,000	0,9
Kazakhstan, concentrate	5,000	0,3
Malaysia	5,000	0,3
World	**1,500,000**	**100,0**

Source: MCS 2022

EU Mn reserves are known in Romania. With a tonnage of 18 million tons of Mn, they represent 1.4% of the world's reserves. Source: European Minerals Yearbook – version 2022.

Uses

More than 90% of Mn is used for the production of manganese ferroalloys used in the field of iron metallurgy, both for the production of pig iron and especially for the production of steel as a deoxidising and desulphurising additive and an important alloying metal. The average world consumption of manganese per 1 ton of crude steel is 10 kg, in modern steel mills it is at least 6 kg. Mn is also used in alloys with non-ferrous metals (Al, Cu, Ti, Ag, Au, Bi). Other uses of Mn are mainly in the production of dry batteries, dyes, soft ferrites, fertilisers, animal feed, fuel additives, welding electrodes, water treatment, etc. In terms of use and quality requirements of ores or concentrates, Mn raw materials are divided into metallurgical, chemical and those for the production of batteries.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

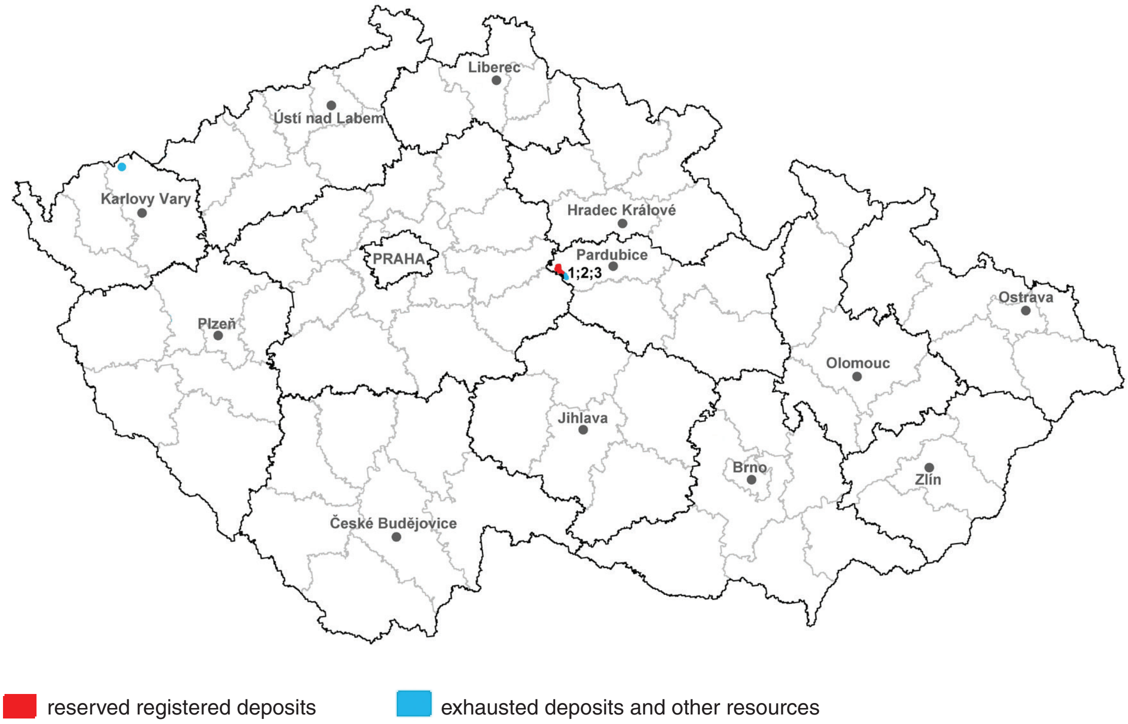
2. Mineral resources of the Czech Republic

Since 1988, the manganese ore reserves in the Register have consisted of one problematic primary deposit of poor carbonate-silicate ores and two dumps (more precisely tailing ponds) in Chvaletice and Řečany. In 2017, the reserves at the tailing ponds were reevaluated, as a result of which the total reserves of Mn ores were reduced to 135.7 million tonnes, but part of the reserves was evaluated as economic. Mn contents in ores mined in the world are around 30–50% in primary ores (mostly metamorphic) and significantly over 10% in sedimentary ores.

- The most significant accumulations of Mn-ores are known in the Iron Mountains area in the form of volcanic-sedimentary deposits in the Proterozoic. The ore mineralisation is connected with the position of graphitic pyrite shales and, together with the surrounding rocks, it is regionally metamorphosed. The ore layer, traceable from Chvaletice to Sovolusky, consists of a mixture of Mn and Fe carbonates (especially Fe-rhodochrosite), quartz, graphite and Fe sulphides. Due to metamorphosis, part of Mn is bound in silicates. The primary ore contains 12 to 13% Mn. The most extensive mining took place at the Chvaletice deposit. In the initial parts of the deposit, Fe ore of the gosan type was initially mined (from the 17th century). Since the First World War, Mn ores were also mined experimentally. From the early 1950s until the end of mining in 1975, pyrite was mined here as a raw material for the chemical industry. Simultaneously mined manganese ores were not processed due to unresolved technology and were deposited in the tailing ponds of the former treatment plant. The average total Mn content at tailing pond 3 is between 9 and 11% and at tailing ponds 1 and 2 it is between 5 and 8%. Leachable Mn accounts for about 6% in all tailing ponds. One of the possible uses of these ores could be flue gas desulphurisation; use in the production of batteries is also being considered at the moment.
- Other occurrences of Mn-ores in the Czech Republic (e.g. Horní Blatná, Arnoštov, Maršov u Veverské Bítýšky, etc.) have no economic significance and they never had any.

Manganese ore mining ended in 1962, when the Chvaletice deposit was last mined. Between 1969 and 1975, there was also a decrease in reserves at the Chvaletice deposit but as a result of pyrite mining, which definitively ended in 1975.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined

1 Chvaletice

2 Chvaletice – tailing ponds No 1 & No 2

3 Řečany – tailing pond No 3

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	3	3	3	3	3
exploited	0	0	0	0	0
Total mineral *reserves, kt ores	135 685	135 685	135 685	135 764	135 764
economic explored reserves	23 372	23 372	23 372	26 495	26 495
economic prospected reserves	3 508	3 508	3 508	464	464
potentially economic reserves	108 805	108 805	108 805	108 805	108 805
Mine production, kt Mn	0	0	0	0	0

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

5. Foreign trade

2602 – Manganese ores and concentrates

		2017	2018	2019	2020	2021
Import	t	33,060	27,292	38,875	38,875	49,576
Export	t	37	57	61	61	71

2602 – Manganese ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/t	3,037	3,782	3,987	4,156	2,479
Average export prices	CZK/t	17,427	15,267	17,799	19,046	17,930

720211; 720219 – Ferromanganese

		2017	2018	2019	2020	2021
Import	t	26,559	26,152	25,089	21,816	27,968
Export	t	1,018	1,176	869	1,263	2,902

720211; 720219 – Ferromanganese

		2017	2018	2019	2020	2021
Average import prices	CZK/t	34,726	29,126	28,490	24,893	27,968
Average export prices	CZK/t	35,861	27,616	28,221	25,368	20,717

720230 – Ferrosilicomanganese

		2017	2018	2019	2020	2021
Import	t	33,972	36,843	44,832	36,389	37,321
Export	t	1,515	1,308	1,548	839	1,762

720230 – Ferrosilicomanganese

		2017	2018	2019	2020	2021
Average import prices	CZK/t	27,841	25,168	17,496	24,232	33,216
Average export prices	CZK/t	27,825	29,513	24,309	20,818	26,868

8111 – Manganese and articles thereof, including waste and scrap

		2017	2018	2019	2020	2021
Import	t	1,235	1,679	960	1,028	1,387
Export	t	60	74	63	77	90

8111 – Manganese and articles thereof, including waste and scrap

		2017	2018	2019	2020	2021
Average import prices	CZK/t	50,111	52,104	60,361	51,336	67,931
Average export prices	CZK/t	55,804	60,564	48,325	42,084	76,625

2820 – Manganese oxides

		2017	2018	2019	2020	2021
Import	t	682	1,057	740	1,093	840
Export	t	37	13	19	8	8

2820 – Manganese oxides

		2017	2018	2019	2020	2021
Average import prices	CZK/t	37,864	25,243	17,901	17,651	17,040
Average export prices	CZK/t	36,223	21,721	36,230	47,663	414,549

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World production

The world´s primary production of manganese in mined ores was as follows in recent years:

	2017	2018	2019	2020	2021^{e}
World mine production of manganese (according to MCS), kt	17,300	18,900	19,600	18,900	20,000
World mine production of manganese (according to WBD), kt	18,936	19,826	21,528	19,277	N

e – preliminary values

Main producers according to MCS

Country	2021e	
	kt	%
South Africa	7,400	37.0
Gabon	3,600	18.0
Australia	3,300	16.5
China	1,300	6.5
Ukraine, concentrate	670	3.4
Ghana	640	3.2
India	600	3.0
Ivory Coast	500	2.5
Brasil	400	2.0
Malaysia	360	1.8
Burma	250	1.3
Mexico	200	1.0
Georgia	190	1.0
Kazakhstan, concentrate	160	0.8
World	**20,000**	**100.0**

e – preliminary values

Prices of traded commodities

According to MCS the average world prices of manganese commodities developed as follows in recent years:

Komodita/rok		2017	2018	2019	2020	2021
Mn ore, metallurgical, 46-48% Mn, CIF USA ports, (MCS)	USD/t	6.43	7.17	6.60	N	N
Mn ore, metallurgical, 44% Mn, CIF Chinese spot market, (MCS)	USD/t	5.97	7.16	5.63	4.59	5.20
Ferro-manganese, 78% Mn, US free market, in warehouse Pittsburgh, (MCS)	USD/lt	1,482	1,458	1,064	1,075–1,360	N
Ferro-managnese, 75%, FOB India (DERA)	USD/t	N	N	N	N	1,387
Electrolytic (EMM), min. 99.7%, export (FOB), domestic (DERA)	USD/t	N	N	N	N	3,929

Nickel

1. Characteristics and use

Average Ni content (and its extent) in the earth's crust (ppm)

99 Ni

Industrially important minerals

Pentlandite $(Ni,Fe)_9S_8$ (35% Ni), nickeline NiAs (44% Ni), garnierite $(Ni,Mg)_6(OH)_8Si_4O_{10}$ (30% Ni)

Industrially important deposit types

1. Sulphide deposits – deposits of disseminated to massive sulphide ores in basic and ultrabasic magmatites: Sudbury, Voisey's Bay (Canada), Norilsk (Russia), Monchegorsk (Russia), Emily Ann (Australia), Flying Fox (Australia), Outokumpu (Finland), Aguablanca (Spain).
2. Silicate – deposits of lateritic ores in basic and ultrabasic massifs, mainly with Co contents: Moa (Cuba), Falcondo (Dominican Republic), Goro (New Caledonia), Petea (Indonesia), Murrin Murrin, Ravensthorpe, (Australia), Shevchenko (Kazakhstan).

Reserve

2021		
Country	**kt**	**% world**
Indonesia	21,000	22.1
Australia	21,000	22.1
Brazil	16,000	16.8
Russia	7,500	7.9
Cuba	4,800	5.1
Philippines	2,800	2.9
Canada	2,000	2.1
China	340	0.4
USA	20,000	21.1
World	**> 95,000**	**100.0**

Source: MCS 2022

2021			
Country	**kt**	**% world**	**% EU**
EU	608	0.6	100.0
Finland	479	0.5	78.8
Poland*	125	0.1	20.6
Spain	4	0.0	0.7

Source: European Minerals Yearbook – version 2022
** Bilans zasobów złóż kopalin w Polsce 2022*

Uses

Nickel excels in high chemical, thermal and mechanical stability, which is the reason it is used as an alloying additive in the production of stainless steels. Their production accounts for most of the world's primary nickel consumption. Furthermore, nickel is used in the automotive industry (NiMH batteries), in aviation, in the nuclear industry, in the energy industry, in the chemical industry, etc.

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved resources of nickel in the total amount of 114,891 t Ni, mainly in the Staré Ransko locality.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2604 – Nickel ores and concentrates

		2017	2018	2019	2020	2021
Import	t	0.1	0	0.004	9	37
Export	t	0.001	0	0	0	0

2604 – Nickel ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/t	527,559	–	475,000	67,699	55,241
Average export prices	CZK/t	8,000,000	–	–	–	–

7502 – Unwrought nickel

		2017	2018	2019	2020	2021
Import	t	2,831	2,871	3,111	2,683	2,851
Export	t	35	211	198	175	124

7502 – Unwrought nickel

		2017	2018	2019	2020	2021
Average import prices	CZK/t	247,602	324,572	338,675	352,008	412,361
Average export prices	CZK/t	252,781	280,721	297,879	298,750	356,520

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of nickel

Commodity/year	2015	2017	2018	2019	2020^{e}
World mine production of nickel (according to MCS), kt*	2,160	2,400	2,610	2,510	2,700
World mine production of nickel (according to WBD), kt	2,142	2,378	2,708	2,492	N

e – estimate

** Nickel content*

Main producers of nickel according to MCS

Country	2021^{e}	
	kt*	%
Indonesia	1,000	37.0
Philippines	370	13.7
Russia	250	9.3
New Caledonia	190	7.0
Australia	160	5.9
Canada	130	4.8
China	120	4.4
Brazil	100	3.7
Cuba	50	1,8
USA	18	0.7
other countries	410	15.1
World total	**2,700**	**100.0**

e – estimate

** Nickel content*

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021[e]
Nickel, annual average, cash, LME, USD/t (MCS)	10,403	13,114	13, 903	14,000	18,000
Nickel, annual average, cash, LME, USD/lb (MCS)	4.719	5.948	6.306	6.400	8.300
Nickel, LME, primary, min. 99.8%, cash in LME warehouse, USD/t (DERA)*	10,403.2	13,113.7	13,902.9	13,772.0	18,475.8

e – estimate

** Average annual price*

Silver

1. Characteristics and use

Average Ag content (and its extent) in the earth's crust (ppm)

(0.02–0.1) Ag

Industrially important minerals

Silver is found in polymetallic (Pb-Zn and Cu) and copper deposits of various types. The main ore mineral in polymetallic deposits is Ag-galenite PbS (0,01 – >1% Ag), the others are mostly Ag sulphides and sulphosalts, such as akantite Ag_2S (87% Ag), polybasite $(Ag,Cu)_{16}Sb_2S_{11}$ (74% Ag), proustite Ag_3AsS_3 (65% Ag), pyrargyrite Ag_3SbS_3 (60% Ag), chlorargyrite AgCl (75% Ag), tetrahedrite (freibergite) $Cu_6(Ag,Fe)_6Sb_4S_{13}$ (18% Ag), native silver (100% Ag).

Industrially important deposit types

Silver production is mainly a by-product of the mining of industrially important deposits of Pb-Zn, Cu.

Reserves

2021		
Country	**t**	**% world**
Peru	120,000	22.6
Australia	90,000	17.0
Poland	67,000	12.6
Russia	45,000	8.5
China	41,000	7.7
Mexico	37,000	7.0
Chile	26,000	4.9
USA	26,000	4.9
Bolivia	22,000	4.2
Others	57,000	10.8
World	**500,000**	**100.0**

Source: MCS 2022

2021			
Country	**t**	**% world**	**% EU**
EU	83 683	16.74	100.0
Poland	70 740	14.10	84.5
Sweden	7 852	1.60	9.4
Portugal	2 619	0.50	3.1
Spain	1 026	0.20	1.2
Slovakia	1 006	0.20	1.2
Finland	439	0.10	0.5

Source: European Minerals Yearbook – version 2022

Uses

Despite the significant decline in silver consumption in the photographic industry in connection with the development of digital photography, its consumption is not significantly decreasing, as this metal finds new applications in many industrial and consumer areas, such as electrical engineering and electronics, colour printing, deodorant production, healthcare etc. The traditional use of silver in jewellery retains its significance (approximately 1/3 of its consumption). Silver is also used in water purification, battery production, production of mirrors and special reflective surfaces (solar energy generation), catalyst production and in nuclear energy for the production of control rods for water reactors (alloy 80% Ag, 15% In and 5% Cd) .

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – no, 2020 – no

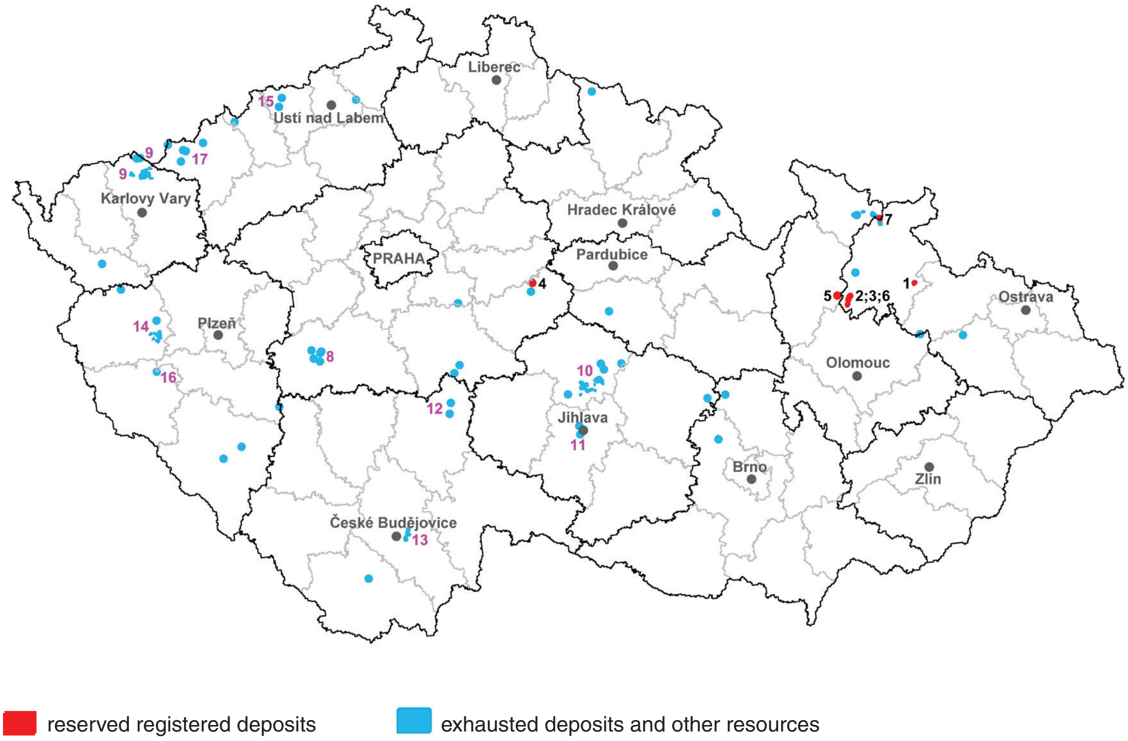
2. Mineral resources of the Czech Republic

Silver mining to a decisive extent established the tradition of medieval ore mining in Bohemia and the expansions of mining towns.

- A substantial share of Ag reserves in the Czech Republic was bound as an isomorphic impurity in sulphides of polymetallic ores, especially in galena. Part of the silver was previously obtained by mining rich polymetallic Pb-Zn ores (58-70 ppm Ag) and U-Ag ores (noble ores including native Ag with contents of about 480 ppm Ag) in the Příbram uranium-polymetallic deposit until the phase out of mining in the early nineties. The obtainable amounts of silver also contained polymetallic ores from the Horní Benešov and Horní Město deposits. The 50% lead concentrate from these deposits showed an average content of 846 g/t Ag in the years 1963–1992, the 49% zinc concentrate had an average content of 86.6 g/t. In the Zlaté Hory district, silver was contained in polymetallic ores of the Zlaté Hory-východ deposit. The average silver content of Pb-Zn concentrate produced from ores of this deposit was 0.19 g/t in the years 1988–1992.
- Many abandoned deposits of Pb-Zn-Ag ores and deposits of five-element formation (U-Bi-Co-Ni-Ag) in historical districts (Kutná Hora, Příbram, Jáchymov, Jihlava, Havlíčkův Brod, Stříbro, Stará Vožice, Ratibořské Hory, Rudolfov, Vejprty, Hrob etc.) was in the past an important source of European silver and represents classical deposit types.

The extraction of Ag from polymetallic deposits was terminated in the Czech Republic in 1993 at the last deposit Zlaté Hory-západ. In connection with the ongoing reassessment of polymetallic ores, a large part of silver deposits and reserves was gradually removed from the Register in 1990–2004.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined

Reserved registered deposits:

1 Horní Benešov
2 Horní Město
3 Horní Město-Šibenice
4 Kutná Hora
5 Oskava
6 Ruda u Rýmařova-sever
7 Zlaté Hory-východ

Exhausted deposits and other resources:

8 Příbram surroundings
9 Jáchymov surroundings
10 Havlíčkův Brod surroundings
11 Jihlava surroundings
12 Ratibořské hory + Stará Vožice
13 Rudolfov
14 Stříbro
15 Hrob + Mikulov
16 Nalžovské hory
17 Vejprty + Hora sv. Kateřiny

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number [a)]	7	7	7	7	7
exploited	0	0	0	0	0
Total mineral *reserves, t Ag	532	532	532	532	532
economic explored reserves	0	0	0	0	0
economic prospected reserves	0	0	0	0	0
potentially economic reserves	532	532	532	532	532
Mine production, t Ag	0	0	0	0	0

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

[a)] *Deposits with registered Ag content*

Approved prognostic resources P_1, P_2, P_3
Ag metal in ores

Year		2017	2018	2019	2020	2021
P_1,	t	33	33	33	33	33
P_2,	t	4	4	4	4	4
P_3		–	–	–	–	–

5. Foreign trade

261610 – Silver ores and concentrates

		2017	2018	2019	2020	2021
Import	kg	0	0	0	1,906	0
Export	kg	9	2	26	0	0

261610 – Silver ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	–	–	–	12	–
Average export prices	CZK/kg	10,888	9,500	2,962	–	–

7106 – Silver, unwrought or in semi-manufactured or powder form

		2017	2018	2019	2020	2021
Import	kg	123,915	33,760	229,138	482,481	569,818
Export	kg	39,649	30,684	36,244	35,995	51,812

7106 – Silver, unwrought or in semi-manufactured or powder form

		2017	2018	2019	2020	2021
Average import prices	CZK/g	7.9	7.9	5.2	4.1	4.9
Average export prices	CZK/g	12.7	8.6	11.3	15.6	16.2

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

According to statistics, world production of primary silver was as follows in recent years:

	2017	2018	2019	2020	2021
World mine production of silver (according to COCHILCO), t	26,251	26,606	26,344	26,413	24,743
World mine production of silver (according to MCS), t	26,800	26,900	26,500	23,500	24,000[e]
World mine production of silver (according to WBD), t	27,035	27,817	28,061	26,248	N

e – preliminary values

COCHILCO (Comisión Chilena del Cobre, Chilean state agency for copper)

Main producers according to COCHILCO

Country	2021	
	t	%
Mexico	5,600	23.3
China	3,400	14.2
Peru	3,000	12.5
Chile	1,600	6.7
Poland	1,300	5.4
Australia	1,300	5.4
Russia	1,300	5.4
USA	1,000	4.2
Bolivia	1,000	4.2
Kazakhstan	450	1.9
World	**24,000**	**100.0**

Prices of traded commodities

According to DERA, MCS and the World Bank (WB), the world silver price in USD/tr oz (1 tr oz (troy ounce) = 31.1035 g) developed as follows in recent years:

Commodity/year	2017	2018	2019	2020	2021
Silver 99.5 %, LME, in warehouse, cash (according to DERA)	16.93*)	15.71	16.19	20.50	25.16
Refined. 99.9 %, Handy&Harman, New York (according to WB)	17.07	15.71	16.22	20.54	25.2
Silver metal, Platts Metal Week quotations (according to MCS)	17.07	15.75	17.17	20.00	25.0

**) Engineering & Mining Journal: 12 monthly quotations average*

Tin

1. Characteristics and use

Average Sn content (and its extent) in the earth's crust (ppm)

2 (0.5–3) Sn

Industrially important minerals

Cassiterite SnO_2, which can contain up to 78% Sn, less often stannite Cu_2FeSnS_4 (28% Sn)

Industrially important deposit types

Tin minerals have been concentrated during magma differentiation, and tin deposits are bound to granitic rocks and their vein and effluent equivalents. Tin ore mineralisation is also known from skarns, which form close to contacts with granitoids. Tin minerals often occur on tin-tungsten, tin-silver and tin-polymetallic deposits.

1. Granites with apical parts enriched with rare earths: Shuiximiao (CHN)
2. Pegmatites with cassiterite and rare earths accompanied by Ta, Be, Li: Greenbushes (Australia)
3. Magmatic-hydrothermal greisens: Cínovec (Czech Republic) – Zinnwald (Germany), Cornwall (United Kingdom)
4. Magmatic-hydrothermal quartz veins, skarns and contact metasomatities: San Rafael (Peru), Dachang (Čína)
5. Alluvial deposits: in Malaysia, Nigeria, Central Africa, Niushipo (China), Dachang District (China)

Reserves

2021		
Country	**kt**	**% world**
China	1,100,000	25.6
Indonesia	800,000	18.6
Australia	430,000	10.0
Brazil	420,000	9.8
Bolivia	400,000	9.3
Russia	280,000	6.5
Congo (Kinshasa)	160,000	3.7
Malaysia	150,000	3.5
Peru	140,000	3.3
Burma	100,000	2.3
Vietnam	11,000	0.3
World	**4,300,000**	**100.0**

Source: MCS 2022

The EU has no registered Sn reserves. Zdroj: European Minerals Yearbook – version 2022.

Uses

The main uses of tin in the EU are for the production of tins and cans (28%), for the production of solders (20%) and chemicals (18%), sheet metal tinning (25%) and for the production of chemicals (20-25%). In the USA, tin is used for tinning and the production of cans (21%), solders (14%), alloys (10%), bearing metal, bronze and brass (11%), others (27%).

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

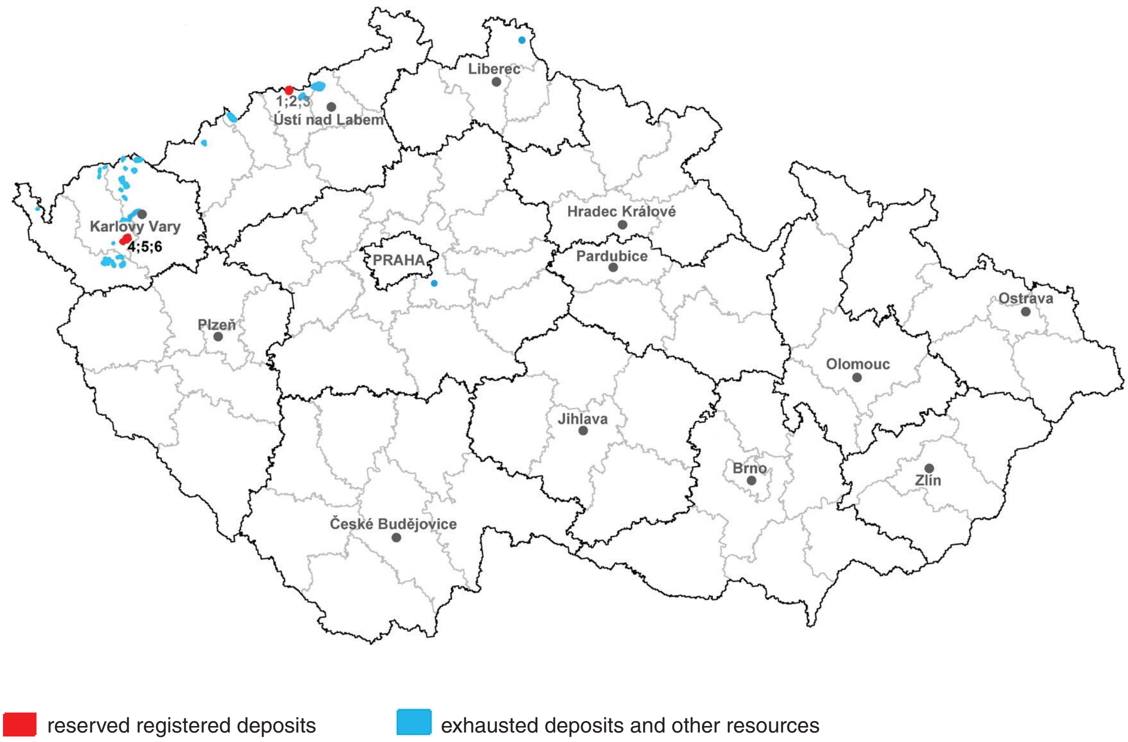
2. Mineral resources of the Czech Republic

With a few exceptions, tin deposits are concentrated almost exclusively in the Ore Mountains, the Slavkov Forest and their foothills, where they have been used since the beginning of the Middle Ages.

- The most important deposit type are the Sn-W (Li) greisen deposits. They occur both in the eastern (Cínovec, Krupka) and in the western part of the Ore Mountains (Rolava, Přebuz) and in the Slavkov Forest (Krásno, Horní Slavkov). The formation of deposits is connected with greisenisation and silicification of elevations of upper Variscan lithium-topaz granites. The main carrier of Sn ore mineralisation is cassiterite, embedded in greisen, accompanied by wolframite and zinwaldite. There is a significant proportion of hydrothermal quartz veins with cassiterite, wolframite, or Bi and Mo minerals in the Krupka and Cínovec districts. Sn-W ores with contents of approx. 0.2–0.5% Sn were mined on greisen and vein deposits.
- An interesting occurrence of tin ores is represented by polymetallic tin-bearing skarns at the former Zlatý Kopec deposit near Boží Dar. Apparently polygenic ores, consisting of magnetite with an admixture of cassiterite (with hulsite and schoenfliesite), sphalerite and chalcopyrite, contain about 0.95% of Sn.
- Basically, the only deposit accumulation of primary ores outside the Ore Mountains area are the stratiform cassiterite-sulphidic ores near Nové Město pod Smrkem. After the Second World War, only a geological survey was carried out on this former deposit, which assessed the average content of 0.23% Sn in the ore here.
- Rather, from the general metallogenetic and mineralogical point of view, the occurrence of Sn-mineralisation deserves attention, formed by stannite in the deeper zones of the "staročeské pásmo" lode in the Kutná Hora mining district, which has a complex character and is not economically significant.

Initially, mining focused on secondary (alluvial) deposits, gradually moving to the primary ones. The tin-bearing alluvial deposits in all areas of the Sn-W ores of the Ore Mountains area and its foothills have been basically completely mined out. Only in the Slavkov Forest and its foothills, small secondary accumulations of cassiterite and wolframite were preserved. Most of the reserves of primary deposits have also been mined out and the rest are currently of no economic significance. Mining of Sn (Sn-W) ores in the Czech Republic ended in 1991 with the closure of the Krásno deposit, and the Cínovec-jih deposit a year earlier. Larger residual reserves of poor-content ores remained only in the deposits in the Krásno – Horní Slavkov and Cínovec districts. In the future, they could also represent a possible source of trace and rare elements, especially of Li, Rb, Cs, or Nb, Ta, Sc, etc.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined.

1 Cínovec-jih	3 Cínovec-severozápad	5 Krásno-Horní Slavkov
2 Cínovec-východ	4 Krásno	6 Krásno-Koník

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number [a)]	6	6	6	6	6
exploited	0	0	0	0	0
Total mineral *reserves, t Sn	386 644	386 644	386 644	386 644	386 644
economic explored reserves	64 099	64 099	64 099	64 099	64 099
economic prospected reserves	66 737	66 737	66 737	66 737	66 737
potentially economic reserves	255 808	255 808	255 808	255 808	255 808
Mine production, t Sn	0	0	0	0	0

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

[a] *Sn-W ore deposits*

Approved prognostic resources P_1, P_2, P_3
Sn metal in ores

Year		2017	2018	2019	2020	2021
P_1,	t	2,960	2,960	2,960	2,960	2,960
P_2		–	–	–	–	–
P_3		–	–	–	–	–

5. Foreign trade

2609 – Tin ores and concretates

		2017	2018	2019	2020	2021
Import	t	4	2	1	2	4
Export	t	0	0	0	0	0

2609 – Tin ores and concretates

		2017	2018	2019	2020	2021
Average import prices	CZK/t	518,382	482,949	465,921	467,139	596,439
Average export prices	CZK/t	–	–	–	–	–

8001 – Unwrought tin

		2017	2018	2019	2020	2021
Import	t	1,012	1,017	928	460	167
Export	t	51	51	62	31	27

8001 – Unwrought tin

		2017	2018	2019	2020	2021
Average import prices	CZK/t	293,471	309,240	300,536	368,573	269,401
Average export prices	CZK/t	78,828	142,104	166,640	178,356	496,823

8002 – Tin waste and scrap

		2017	2018	2019	2020	2021
Import	t	23	13	19	15	7
Export	t	94	84	83	65	98

8002 – Tin waste and scrap

		2017	2018	2019	2020	2021
Average import prices	CZK/t	529,185	456,195	275,104	465,113	569,069
Average export prices	CZK/t	392,222	414,104	456,855	421,390	469,208

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

World production of primary tin was as follows in recent years:

	2017	2018	2019	2020	2021e
World mine production of tin (according to MCS), kt	313	318	296	264	300
World mine production of tin (according to WBD), kt	316	317	295	277	N
World mine production of tin (according to WMS), kt	337	325	311	278	N

e – preliminary values

Main producers according to MCS

Country	2021e	
	t	%
China	91,000	30.3
Indonesia	71,000	23.7
Peru	30,000	10.0
Burma	28,000	9.3
Brazil	22,000	7.3
Bolivia	18,000	6.0
Congo (Kinshasa)	17,000	5.7
Australia	8,300	2.8
Vietnam	4,900	1.6
Russia	3,500	1.2
Malaysia	3,100	1.0
Nigeria	1,200	0.4
World	**300,000**	**100.0**

e – preliminary values

The world's largest producers of refined tin in 2021 (according to the International Tin Association)

1. Yunnan Tin (China)
2. Minsur (Peru)
3. PT Timah (Indonesia)
4. Yunnan Chengfeng (China)
5. MSC (Malaysia)
6. Thaisarco (Thailand)
7. EM Vinto (Bolivia)
8. Jiangxi New Nanshan (China)
9. Aubris Beerse (Belgium)
10. Guangxi China Tin (China)

Prices of traded commodities

According to 2018–2022 (DERA) yearbooks and the World Bank (WB), the world´s tin prices in USD/t developed as follows:

Commodity/year	2017	2018	2019	2020	2021
Tin, min. 99.85%, LME, in warehouse, cash (according to DERA)	20,185*	20,251	18,660	17,133	32,587
High grade min. 99,85%, LME contractual (WB)	20,061	20,145	18,661	17,125	32,384

**) Engineering & Mining Journal: 12 monthly quotations average*

Tungsten

1. Characteristics and use

Average W content (and its extent) in the earth's crust (ppm)

1 (0.4–70) W

Industrially important minerals

Wolframite (Mn,Fe)WO_4 (with 76.5% WO_3), scheelite $CaWO_4$ (with 80.6% WO_3)

Industrially important deposit types

1. Skarns: King Island (Australia), Baoshan (China), Footweg (Canada), Pine Creek (USA)
2. Greisens: Cínovec-Zinnwald (Czechia – Germany, Panasqueira (Portugal), Hongshuizhai (China)
3. Magmatic-hydrothermal: Climax (USA), Lianhuashan (China), Jeddah (Russia), Endako (Canada), Mittersill (Austria)

Reserves

2021		
Country	**Mill t**	**%**
China	1,900,000	55.9
Russia	400,000	11.8
Vietnam	95,000	2.8
Spain	54,000	1.6
North Korea	29,000	0.9
Austria	10,000	0.3
Portugal	4,300	0.1
others	3,100	0.1
World	**3,400,000**	**100.0**

Source: MCS 2022

2021			
Country	**Mill t**	**% world**	**% EU**
EU	67 100	2.0	100.0
Spain	54 000	1.6	80.5
Austria	10 000	0.3	14.9
Portugal	3 100	0.1	4.6

Source: MCS 2022

Uses

Cutting tools (cemented carbides), tungsten steels, high-speed cutting steels, special stainless steels, metallic tungsten (lighting, heating resistors, ammunition), superalloys (aviation, gas turbines), chemicals.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes

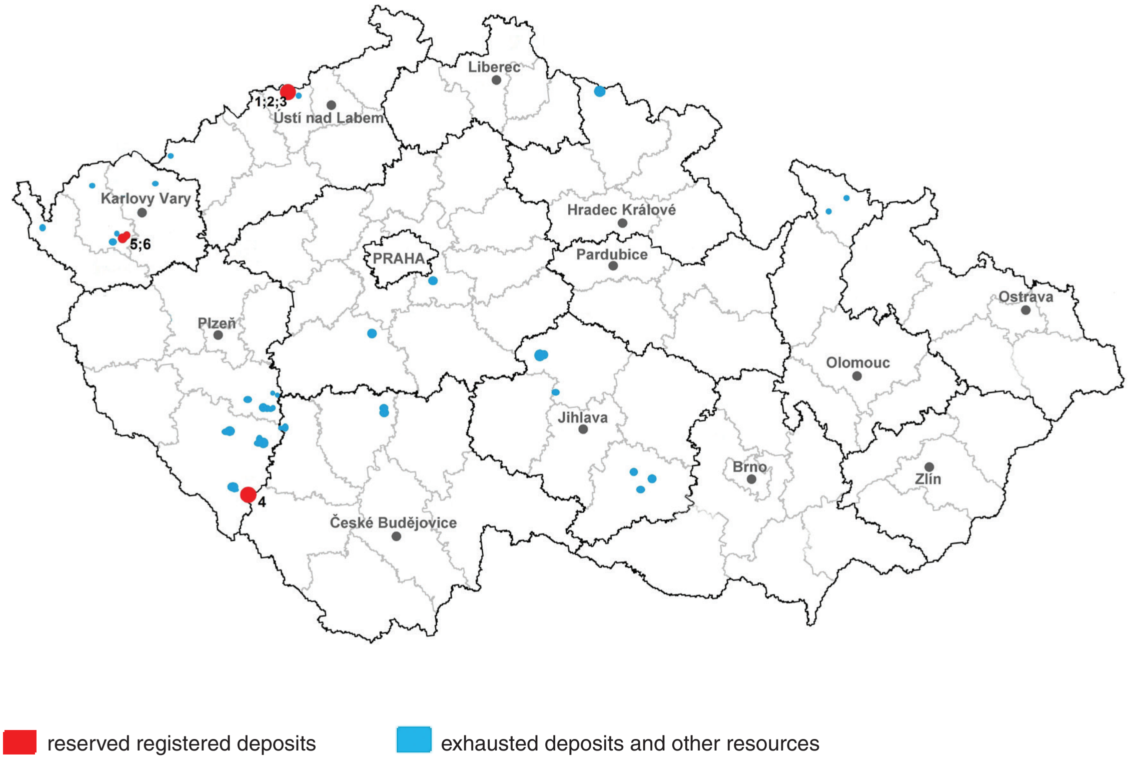
2. Mineral resources of the Czech Republic

In the Czech Republic, tungsten concentrate was obtained as a by-product in the mining and processing of vein and greisen Sn-W ores in the Cínovec (where Li (+ Rb) ore mineralisation associated with cinvaldite and other lithium micas is particularly important) and Krásno districts. In addition, especially in recent years, a number of occurrences of W-mineralisation in the form of scheelite or wolframite ores have been verified in various parts of the Bohemian Massif. Mining of W ores in the Czech Republic ended together with Sn ores in 1990 at the Cínovec deposit and a year later at the Krásno deposit. Some small occurrences of scheelites in the Moldanubicum were mined during the survey in the late 1980s and early 1990s (Malý Bor-Vrbík, Nekvasovy-Chlumy).

- In the Krušné hory Mts. (Ore Mountains) area, quartz veins and greisens occur mainly with a predominance of Sn (Cínovec, Krásno, Horní Slavkov), less with a predominance of W (Krupka 4). Greisen ores usually have a content of 0.02–0.07% W, only in the former Krupka 4 deposit it was 0.1–0.2% W. Total registered reserves of almost 100 kt W of metal in the deposits of the Cínovec district (92 kt W) and Krásno – Horní Slavkov (7 kt W) are seemingly high, but tungsten forms only an accompanying and independently unminable and unrecoverable component of complex Li-Sn-W ores. Furthermore, wolframite ore mineralisation in quartz veins and stockworks (Rotava) and scheelite inclusions in erlanes (= Ca-pyroxenic gneisses) are known here (Vykmanov at Perštejn).
- A number of, mostly small, new resources of W ores have been verified in the Moldanubicum. They are represented by quartz veins with tungsten or scheelite mainly in exocontacts of Variscan granitoids and scheelite disseminations and veinlets bound to the layers of erlane rocks. Some objects have the character of larger stratiform deposits of the type of scheelite-bearing crystalline shales, eventually skarns. Scheelite W ores often occur together with vein Au ores, which are genetically and mostly spatially separated. So far, the most significant occurrence of the stratiform type of ore mineralisation is the Au, W ore deposit of Kašperské Hory. Scheelite here forms disseminations and ore strips in silicified layers in the footwall of gold-bearing quartz veins. The average content of W in the ore is high – 0.55% (minimum metal content of the ore – cutoff grade = 0.1% W) to 1.32% (cutoff grade = 0.3% W). This corresponds to the variant reserves of W ores in the amount of 10 million t with 54.9 kt W, respectively 3.1 million t with 41.6 kt W. Prognostic resources of W ores with a lower average metal content of 0.24% (cutoff grade = 0.1% W) to 0.48% (cutoff grade = 0.2%) are also calculated on the deposit in the amount of 2.1 million tonnes of ore with 5.0 kt W, respectively 0.7 million tonnes of ore with 3.3 kt W. Although all reserves are potentially economic due to conflicts of interest with nature protection, the Kašperské Hory probably represent the only currently economically usable deposit of W and Au ores in the Czech Republic. It is a complex deposit of Au and W ores, and thus large and important from a European point of view. Other smaller prognostic resources of W ores, often together with Au, are in the closer (Hartmanice, Horažďovice area) and more distant surroundings (Sepekov, Mokrsko, Čelina, etc.).
- Typical contact metasomatic scheelite ore mineralisation is developed in the exocontacts of the Krkonoše-Jizera and Žulová plutons, but the known localities (Obří důl, Vápenná) have no practical significance.
- In connection with the development of survey methods, a number of genetically not yet fully clarified occurrences of W-ores have been found in the Czech Republic. Contrary

to previous notions, it has been shown that wolframite or scheelite ores occur mainly independently and only to a limited extent belong to the mixed type of Sn-W ores.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined

1 Cínovec-jih	4 Kašperské Hory
2 Cínovec-severozápad	5 Krásno
3 Cínovec-východ	6 Krásno-Horní Slavkov

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number [a)]	4	6	6	6	6
exploited	0	0	0	0	0
Total mineral *reserves, t W	71 904	140 799	140 799	140 799	140 799
economic explored reserves	0	21 508	21 508	21 508	21 508
economic prospected reserves	865	19 131	19 131	19 131	19 131
potentially economic reserves	71 039	100 160	100 160	100 160	100 160
Mine production, t W	0	0	0	0	0

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

[a)] *Sn-W and W ore deposits*

Approved prognostic resources P_1, P_2, P_3
W metal in ores

Year		2017	2018	2019	2020	2021
P_1,	t	–	–	–	–	–
P_2,	t	19 791	19 791	19 791	19 791	19 791
P_3		–	–	–	–	–

5. Foreign trade

2611 – Tungsten ores and concentrates

		2017	2018	2019	2020	2021
Import	kg	804	0	0	0	0
Export	kg	2,535	0	0	0	0

2611 – Tungsten ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	182	–	–	–	–
Average export prices	CZK/kg	547	–	–	–	–

8101 – Tungsten and its products, including waste and scrap

		2017	2018	2019	2020	2021
Import	kg	675,047	923,140	695,253	240,849	378,244
Export	kg	1,067,999	1,531,247	931,960	1,060,611	1,152,964

8101 – Tungsten and its products, including waste and scrap

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	639.9	606.1	300.5	588.1	884.3
Average export prices	CZK/kg	793.0	783.7	896.5	676.2	805.1

720280 – Ferro-tungsten and ferrosilicotungsten

		2017	2018	2019	2020	2021
Import	kg	12,359	35,685	16,863	34,518	72,477
Export	kg	4,504	20,872	10,969	25,462	33,413

720280 – Ferro-tungsten and ferrosilicotungsten

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	524,4	733,6	568,8	467.2	547.3
Average export prices	CZK/kg	546,0	682,4	591,3	475.1	556.2

810196 – Tungsten wires

		2017	2018	2019	2020	2021
Import	kg	63,988	71,959	61,342	42,080	37,965
Export	kg	29,769	33,626	24,959	20,082	23,281

810196 – Tungsten wires

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	2,356	2,016	1,935	2,661	3,143
Average export prices	CZK/kg	3,872	3,329	5,506	5,125	5,083

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

World production of primary tungsten

	2017	2018	2019	2020	2021^{e}
Mine production, kt (according to MCS)	82.1	81.1	83.8	78.4	79.0
Mine production, kt (according to WBD)	86.7	84.1	89.0	87.5	N

e – preliminary values

Main producers according to MCS

Country	2021^{e}	
	kt	%
China	66,000	83.5
Vietnam	4,500	5.7
Russia	2,400	3.0
Bolivia	1,400	1.8
Rwanda	950	1.2
Austria	900	1.1
Spain	900	1.1
Portugal	620	0.8
others	1,200	1.5
World	**79,000**	**100.0**

e – preliminary values

Prices of traded commodities

According to Metalary (http://www.metalary.com//tungsten.price/), annual tungsten prices were as follows (USD/t):

Commodity/year		2017	2018	2019	2020	2021
Tungsten metal	USD/ mtu W	35,200	30,300	31,000	N	N
Wolframite concentrate, min. 65% WO_3, American spot market (MCS)	USD/ mtu WO_3	245	326	270	270	270
Concentrate 65% WO_3 in warehouse China	CNY(RMB)/ t	87,600–90,851*	99,000–116,000*	71,000–99,000*	75,000–95,000*	N
	USD/ mtu WO_3	129.55–134.35*	146.41–171.54*	102.75–143.27*	108.50–137.50*	N
Average exchange rate	CNY(RMB)/ USD	6.76**	6.62**	6.91**	6.90**	6.45
Ferro-Tungsten, basis min. 75% W, in warehouse Rotterdam	USD/kg W	30.1*	37.25	30.99	28.90	38.85
APT. European free market	USD/mtu WO_3	236–248*	299.29	271.37	219.50	279.15

Note: mtu – metric ton unit; 1 mtu = 1% = 10 kg WO_3 in 1 t of concentrate
** Metal Bulletin. price average*
*** Kurzy.cz (https://www.kurzy.cz)*
Yearly average prices or annual price ranges
RMB – Renminbi (= People's Currency) – officially CNY – Chinese yuan
Source: MCS, DERA Preismonitor 2020–2021, Metal Bulletin

Zinc

1. Characteristics and use

Average Zn content (and its extent) in the earth's crust (ppm)

70 (40–200) Zn

Industrially important minerals

The main ore mineral is ZnS sphalerite (38 – 67% Zn), which usually accompanies galena, pyrite and chalcopyrite in polymetallic deposits. An ore is considered a zinc ore if its content ratio is Zn:Pb > 4. Sphalerite in most cases contains cadmium from trace contents up to 2%, germanium, gallium, indium and thallium. Zinc ores occur most often in polymetallic deposits of various genetic types, similar to lead ores.

Industrially important deposit types

1. Sedimentary exhalative (sediment-bound, submarine-exhalative – "sedex"): Mt.Isa (Australia), Broken Hill (Australia), Gorevskoye (Russia), Xiaotieshan (China), Maqiongxia (China)
2. Stratiform: Olkusz (Poland), Mississippi Valley (USA), Silvermines (Ireland), Mirgalimsay (Kazakhstan), Frankou (China), Siding (China)

Reserves

2021		
Country	**kt**	**% world**
Australia	68,000	27.2
China	44,000	17.6
Mexico	22,000	8.8
Russia	22,000	8.8
Peru	20,000	8.0
Kazakhstan	12,000	4.8
USA	11,000	4.4
India	10,000	4.0
Bolivia	4,800	1.9
Sweden	3,600	1.4
Canada	2,300	0.9
World	**250 000**	**100.0**

Source: MCS 2021

2021			
Country	**kt**	**% world**	**% EU**
EU	10,440	4.20	100.0
Sweden	3,493	1.40	33.5
Italy	3,400	1.40	32.6
Portugal	1,927	0.80	18.5
Ireland	1,092	0.40	10.5
Poland	340	0.10	3.3
Finland	189	0.08	1.8
Slovakia	45	0.02	0.4

Source: European Minerals Yearbook – version 2021

Uses

About 51% of zinc is consumed in galvanisation, about 34% goes to the production of alloys. About 13% is used for the production of brass and bronze and about 15% is consumed for other purposes (electrical equipment 10%).

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

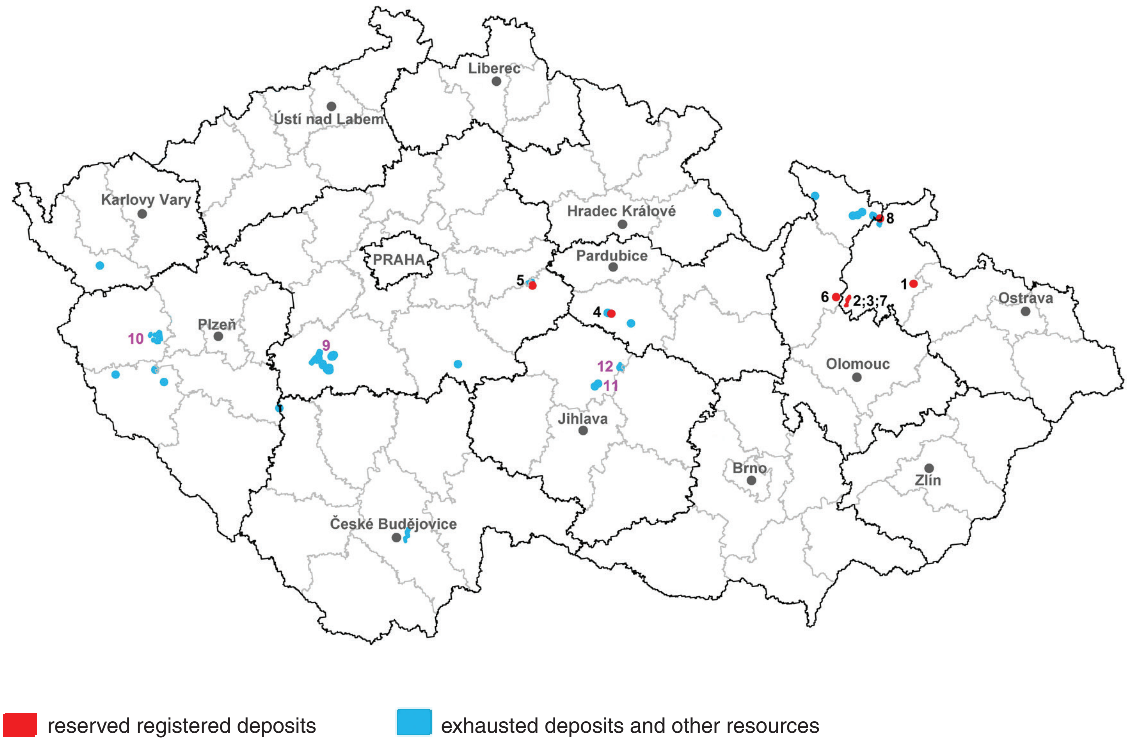
2. Mineral resources of the Czech Republic

Zinc ores occur in the Bohemian Massif almost exclusively as part of polymetallic Pb-Zn±Ag(±Cu) ores of hydrothermal or volcanic-sedimentary type.

- A significant proportion of Zn ores, represented mainly by sphalerite, was previously obtained in the former deposits of the Březové Hory, Bohutín and Vrančice districts in the vicinity of Příbram (until 1962). The Zn content of ores in these deposits ranged from 1.0 to 2.9%. Deposits in the northern part of the Kutná Hora district (Rejské, Turkaňské and Staročeské lodes), in the Havlíčkův Brod district (Stříbrné Hory, Dlouhá Ves, Bartoušov) and in western Bohemia (Stříbro, Kšice) were explored and partially mined from other venous deposits of polymetallic ores.
- The most important polymetallic deposits of volcanic-sedimentary origin were located in the Jeseníky Mountains. Disseminated sulphide ores with a content of 1.1–1.8% Zn were mined in Horní Město (1967–1970) and Horní Benešov (1963–1992) deposits. Between 1963 and 1992, a total of 6,561 kt of ore containing 39,210 t of lead and 90,711 t of zinc was extracted from both deposits. In the Zlaté Hory district, the extraction of Au Zn ores was terminated at the Zlaté Hory-západ deposit in 1994. In the years 1988–1994, a total of 771.6 kt of polymetallic ores containing 9,111 t Zn, 395 t Pb and 1,559 kg Au were mined in the Zlaté Hory-východ and Zlaté Hory-západ deposits.
- The former Staré Ransko-Obrázek deposit is probably polygenetic – sphalerite-barite ore with a content of up to 1.8% Zn was mined there until 1990. Genetically unclear types also include the Pb-Zn-Cu ore deposit with barite in Křižanovice, with contents of about 4–6% Zn, verified by exploration in the 1980s.

Mining of Zn ores in accordance with the concept of phase-out of ore mining in the Czech Republic ended at the beginning of 1994 at the last deposit Zlaté Hory-západ. The final product of polymetallic ore mining was a complex Pb-Zn concentrate, which was exported because there were no domestic capacities to smelt it. In connection with the ongoing reassessment (reregistration) of polymetallic ores, a large part of zinc deposits and reserves was gradually removed from the Register in 1990–2004.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined

Reserved registered deposits:

1 Horní Benešov
2 Horní Město
3 Horní Město-Šibenice
4 Křižanovice
5 Kutná Hora
6 Oskava
7 Ruda u Rýmařova-sever
8 Zlaté Hory-východ

Exhausted deposits and other resources:

9 Březové Hory + Příbram + Bohutín
10 Stříbro
11 Havlíčkův Brod (Dlouhá Ves + Bartoušov + Stříbrné Hory)
12 Staré Ransko

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number [a)]	8	8	8	8	8
exploited	0	0	0	0	0
Total mineral *reserves, kt Zn	559	559	559	559	559
economic explored reserves	0	0	0	0	0
economic prospected reserves	0	0	0	0	0
potentially economic reserves	559	559	559	559	559
Mine production, t Zn	0	0	0	0	0

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

[a)] Deposits with registered Zn content

5. Foreign trade

2608 – Zinc ores and concentrates

		2017	2018	2019	2020	2021
Import	t	14	11	11	17	12
Export	t	2	43	1	0	0

2608 – Zinc ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/t	111,692	82,571	82,818	58,567	84,416
Average export prices	CZK/t	84,424	3,256	58,000	–	–

7901 – Unwrought zinc

		2017	2018	2019	2020	2021
Import	t	37,976	33,214	33,964	33,369	37,187
Export	t	4,753	3,582	1 498	1,299	925

7901 – Unwrought zinc

		2017	2018	2019	2020	2021
Average import prices	CZK/t	71,256	69,354	63,741	55,858	67,835
Average export prices	CZK/t	69,465	65,241	57,327	51,425	55,666

7902 – Zinc waste and scrap

		2017	2018	2019	2020	2021
Import	t	1,102	966	350	467	693
Export	t	3,005	3,446	3,168	2,767	3,260

7902 – Zinc waste and scrap

		2017	2018	2019	2020	2021
Average import prices	CZK/t	20,324	22,159	39,781	44,356	67,835
Average export prices	CZK/t	48,584,	47,699	41,469	35,575	43,695

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

World production of primary zinc has basically stagnated over the last four years. The table shows data from the prestigious International Lead and Zinc Study Group (ILZSG) and data from the Mineral Commodity Summary (MCS) and Welt Bergbau Daten (WBD) yearbooks:

	2017	2018	2019	2020	2021^{e}
Mine production of zinc, kt (according to ILZSG)	12,683	12,743	12,816	12,274	12,799
Mine production of zinc, kt (according to MCS)	12,500	12,500	12,700	12,000	13,000
Mine production of zinc, kt (according to WBD)	12,870	12,212	13,086	12,608	N

e – preliminary values

Main producers according to MCS

Country	2021^e	
	kt	%
China	4,200	32.3
Australia	1,600	12.3
Peru	1,300	10.0
India	810	6.2
USA	740	5.7
Mexico	720	5.5
Bolivia	490	3.8
Russia	280	2.2
Canada	260	2.0
Kazakhstan	220	1.7
Others	2,000	15.4
World	**13,000**	**100.0**

e – preliminary values

Prices of traded commodities

According to DERA, World Bank (WB), and Metal Bulletin (MB), world zinc prices in USD/t developed as follows:

Commodity/year	2017	2018	2019	2020	2021
Special high grade, min. 99.995% cash, LME, in warehouse (according to DERA)	2,833.92*	2,924.55	2,548.34	2,263.90	3,003.92
High quality min. 99.95 %, LME contractual price (according to WB)	2,891	2,922	2,550	2,266	3,003
Zinc, annual average, American market, USc/lb (according to MCS)	139.3	141.0	124.1	109.0	145.0

**) Engineering & Mining Journal: 12 monthly quotations average*

MINERALS MINED IN THE PAST WITHOUT RESOURCES AND RESERVES

Antimony

1. Characteristics and use

Average Sb content (and its extent) in the earth's crust (ppm)

0.2 (0.15–1) Sb

Industrially important minerals

Stibnite (antimonite) Sb_2S_3 (71% Sb), tetrahedrite $Cu(Ag,Fe,Zn)_3Sb(As,Bi)S_{3.25}$ (very approximately 29% Sb)

Industrially important deposit types

1. Stratiform sedimentary exhalative deposits ("sedex"): Gravelotte, United Jack (South Africa), Xikuangshan (China), Sarylach (Russia), Kadamjay (Kyrgyzstan), Costerfield (Australia)
2. Deposits of vein, stockwork and disseminated polymetallic ores mainly with antimonite, also Hg, Au, Sn and W ores with antimonite in carbonate rocks: Xian (China), Sunshine (USA), Bohutín (Czech Republic), Dúbrava, Rudňany (Slovakia), Baia Mare (Romania).

Reserves

2021		
Country	**t**	**% world**
China	480,000	25.3
Russia	350,000	18.4
Bolivia	310,000	16.3
Kyrgyzstan	260,000	13.7
Australia	100,000	7.4
Turkey	100,000	5.3
Canada	78,000	4.1
USA	60,000	3.2
Tajikistan	50,000	2.6
Pakistan	26,000	1.4
Mexico	18,000	0.9
World	**1,900,000**	**100.0**

Source: MCS 2021

Sb reserves in the EU are known in Slovakia. With their tonnage of 2.5 kt Sb, they represent 0.1% of the world reserves (European Minerals Yearbook – version 2021).

Uses

Antimony is most often used in alloys with lead, copper and zinc, which it provides with strength, hardness and anti-corrosion properties. The majority of Sb consumption is due to its non-flammable compounds, which are used for the production of fire extinguishing mixtures. Significant amounts (around 10–15%) are used for the production of batteries, as well as in the chemical, ceramic and glass industries.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of antimony.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

261710 – Antimony ores and concentrates

		2017	2018	2019	2020	2021
Import	kg	8,500	8,897	12,521	14,019	8,179
Export	kg	0	0	0	0	0

261710 – Antimony ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	156	184	249	208	364
Average export prices	CZK/kg	–	–	–	–	–

8110 – Antimony and articles thereof, including waste and scrap

		2017	2018	2019	2020	2021
Import	t	102	103	101	49	52
Export	t	0	0,01	0,3	0,4	2

8110 – Antimony and articles thereof, including waste and scrap

		2017	2018	2019	2020	2021
Average import prices	CZK/t	220,720	201,281	184,581	159,638	264,878
Average export prices	CZK/t	–	333,333	128,280	1 302,500	455,392

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

Trend in the world´s primary antimony production in 2017–2021

	2017	2018	2019	2020	2021^e
Mine production of antimony, kt (according to MCS)	137	147	162	111	110
Mine production of antimony, kt (according to WBD)	149	145	134	128	N

e – preliminary values

Main producers according to MCS

Country	2021^e	
	t	%
China	60,000	54.5
Russia	25,000	22.7
Tajikistan	13,000	11.8
Australia	3,400	3.1
Bolivia	2,700	2.5
Burma	2,200	2.0
Turkey	1,300	1.2
other countries	2,400	2.2
World	**110,000**	**100.0**

e – preliminary values

Prices of traded commodities according to IM (USD/t) and MCS (USD/lb)

Commodity/year	2017	2018	2019	2020	2021
Antimony, purity 99.65%, CIF US ports (according to MCS), USD/lb	3.77	3.81	3.04	2.67	5.20

Arsenic

1. Characteristics and use

Average As content (and its extent) in the earth's crust (ppm)

2 (1.7–5) As

Industrially important minerals

Arsenopyrite FeAsS (46% As), löllingite $FeAs_2$ (73% As)

Industrially important deposit types

Arsenic is a minor component of polymetallic, copper, gold-bearing, tin and cobalt-nickel ores.

Reserves

Data on global reserves of As are not published, but it is assumed that they correspond to twenty times the global extraction, i.e. about 650 kt of As_2O_3 (MCS 2021). Reserves of As in the EU are not known (European Minerals Yearbook – version 2021), but Poland reports 20 kt of As reserves in its territory (Bilans zasobów złóż kopalin w Polsce 2021).

Uses

In the production of chemical wood preservatives, lead-acid batteries, bearing lubricants, herbicides and insecticides. High-purity arsenic (99.9999%) is used to produce gallium arsenide (GaAs) semiconductors. As is used in solar cells, space research and telecommunications. Arsenic is also used for germanium-arsenide-selenide special optical materials. Indium-gallium-arsenide (InGaAs) is used for shortwave infrared technology.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of arsenic.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

280480 – Arsenic

		2017	2018	2019	2020	2021
Import	kg	10,287	8,182	8,118	8,169	8,499
Export	kg	0	0	0	0	0

280480 – Arsenic

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	166	212	117	174	193
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World production and world market prices

The volume of world production reported by WBD has been significantly higher since 2016, as it also includes the relatively high production of Peru (20 to 25 kt/y), which MCS does not take into account. World production of primary arsenic was as follows in recent years:

	2017	2018	2019	2020	2021^{e}
World production of arsenic, kt (according to MCS)	34.6	33.4	32.3	60.0	59.0
World production of arsenic, kt (according to WBD)	57.4	51.7	55.2	51.9	N

e – preliminary values

Main producers according to MCS

Country	2021[e]	
	kt	%
China	24,000	46.2
Peru	19,014	36.6
Morocco	7,694	14.8
Belgium	1,000	1.9
Russia	100	0.2
Bolivia	50	0.1
World	**51,898**	**100.0**

e – preliminary values

Prices of traded commodities

According to the Mineral Commodity Summaries (MCS), prices ranged as follows:

Commodity/year	2017	2018	2019	2020	2021
Arsenic metal, China, USD/kg (MCS)	1.56	1.43	1.92	1.51	1.28

Mercury

1. Characteristics and use

Average Hg content (and its extent) in the earth's crust (ppm)

0.08 (0.03–0.5) Hg

Industrially important minerals

Cinnabar HgS (86% Hg), schwazite (Hg rich tetrahedrite) $(Cu,Hg)_3SbS_{3-4}$ and many sulphides and sulphosalts of other metals (e.g. Sb, As, Cu, Fe)

Industrially important deposit types

1. Volcanogenic-hydrothermal: Almadén (Spain), Red Level (USA), Nikitovka (Ukraine), Idrija (Slovenia), Sulphur Bank (USA)
2. Plutogenic-hydrothermal: Chajdarkan (Russia), Jijikrut (Russia), Tamvatnyj (Russia)

Reserves

A quantitative estimate of world Hg reserves is not available, China, Kyrgyzstan and Peru are expected to have the largest reserves (MCS 2021). The EU has known reserves only in Croatia, namely 3.8 kt Hg (European Minerals Yearbook – version 2021).

Uses

Globally, mercury mining has almost stopped due to the health risks of its use. It is still used in the field of chemistry and in electrical and electronic applications.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of mercury.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

280540 – Mercury

		2017	2018	2019	2020	2021
Import	kg	2,215	5,426	6,751	20,225	704
Export	kg	140	8,651	4,211	89,069	59,792

280540 – Mercury

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	657	312	317	233	439
Average export prices	CZK/kg	1,414	593	1,159	1	2

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

World mine production of mercury (t)

	2017	2018	2019	2020	2021e
World mine production of mercury (according to MCS)	3,790	4,060	3,900	2,490	2,300
World mine production of mercury (according to WBD)	2,396	2,864	2,313	2,290	N

e – preliminary values

Main producers according to MCS

Country	2021^e	
	t	%
China	2,000	80.3
Tajikistan	170	6.8
Mexico	40	1.6
Argentina	30	1.2
Peru	20	0.8
Norway	15	0.6
Kyrgyzstan	11	0.4
World	**2,490**	**100.0**

e – preliminary values

Prices of traded commodities

Annual prices according to MCS yearbook

Commodity/Year		2017	2018	2019	2020	2021
Mercury, min. 99.99%, EU market, annual average (MCS)	USD/flask	1,041	1,100	N	N	N
Mercury, 99.99% in warehouse, avg. midpoint of free market global locations.	USD/flask	1,273	2,709	2,550	N	N

** 1 flask (láhev) rtuti je ekvivalent 34,473 kg*

Sulphur

1. Characteristics and use

Average S content (and its extent) in the earth's crust (ppm)
500 (260–1 200) S

Industrially important minerals
Pure sulphur, sulphides and sulphosalts

Industrially important deposit types
Sulphur is in some cases a by-product of smelting, especially of polymetallic and copper ores. But it is mainly a product of petrochemistry, desulphurisation of oil and natural gas.

The mined sulphur deposits are either volcanic (Volcano, Italy) or mainly bound to evaporites (Calcanisetta Basin, Italy, Gulf of Mexico, USA, Osiek, Poland).

Reserves
World reserves of sulphur in oil, natural gas and sulphide ores are extensive. Most of the sulphur produced comes from oil and gas processing. In the EU, only Poland has sulphur reserves in the form of rocks, namely 494 million tonnes (Bilans zasobów złóż kopalin w Polsce 2021).

Uses
Production of sulphuric acid, essential raw material for industrial production, especially fertiliser production. Consumption of sulphuric acid was considered as one of the best indicators of the country's degree of industrial development.

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any resources of sulphur.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2503 – Sulphur of all kinds, other than sublimed, precipitated and colloidal

		2017	2018	2019	2020	2021
Import	t	72,711	70,374	65,190	71,918	74,497
Export	t	1,843	5,738	8,193	5,954	9,262

2503 – Sulphur of all kinds, other than sublimed, precipitated and colloidal

		2017	2018	2019	2020	2021
Average import prices	CZK/t	2,707	2,835	2,735	2,650	3,082
Average export prices	CZK/t	2,960	2,054	2,535	2,707	3,182

2802 – Sulphur, sublimed or precipitated; colloidal sulphur

		2017	2018	2019	2020	2021
Import	t	29,508	35,976	40,745	43,006	45,596
Export	t	1	2	0.4	0.1	0.1

2802 – Sulphur, sublimed or precipitated; colloidal sulphur

		2017	2018	2019	2020	2021
Average import prices	CZK/t	1,825	1,737	1,843	1,802	1,950
Average export prices	CZK/t	162,441	157,191	217,742	291,667	400,000

2807 – Sulphuric acid

		2017	2018	2019	2020	2021
Import	t	45,711	34,655	55,506	28,307	49,283
Export	t	70,399	77,389	81,669	66,358	64,732

2807 – Sulphuric acid

		2017	2018	2019	2020	2021
Average import prices	CZK/t	1,587	3,034	2,246	2,509	2,286
Average export prices	CZK/t	1,506	1,364	1,562	1,755	2,175

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

World sulfur production, which comes mainly from the processing of liquid and gaseous hydrocarbons, has had a slightly upward trend for many years, is rather stagnating in recent years:

	2017	2018	2019	2020	2021^e
World sulphur production (according to MCS), kt	80,200	79,400	80,000	79,800	80,000
World sulphur production (according to WBD), kt	79,348	81,223	81,548	77,978	N

e – preliminary values

Main producers according to MCS

Country	2021^e	
	kt	%
China	17,000	21.3
USA	8,100	10.1
Russia	7,500	9.4
Saudi Arabia	6,500	8.1
United Arab Emirates	6,000	7.5
Canada	4,900	6.1
Kazakhstan	4,500	5.6
India	3,500	4.4
South Korea	3,100	3.9
Japan	3,000	3.8
Iran	2,200	2.8
other countries	13,700	17.1
World	**80,000**	**100.0**

e – preliminary values

Prices of sulphur according to Industrial Minerals (IM) and MCS in USD/t

Commodity/year		2017	2018	2019	2020	2021
Canadian, solid, spot price, FOB, Vancouver	AgM	140–155	140–155	40–130	40–80	90–140
Middle East, FOB	AgM	119–135	119–135	40–130	40–80	80–120
Reported US average price, FOB, mine and/or plant, elemental sulphur	MCS	46.40	81.16	51.08	24.40	90.00

MINERALS UNMINED IN THE PAST WITH RESOURCES AND RESERVES

Lithium, rubidium and cesium

1. Characteristics and use

Lithium, rubidium and cesium have close chemical properties and to a large extent, they occur together.

Lithium

Average content (and its extent) in the earth's crust (ppm)

30 (18–65) Li

Industrially important minerals

Spodumen $LiALSi_2O_6$ (contains 5.8–7.6% Li_2O), lepidolite $K_2Li_4Al_2[(F,OH)_2Si_4O_{10}]_2$ (contains 3.2–4.4% Li_2O), petalite $LiAlSi_4O_{10}$ (contains 3.4–4.1% Li_2O)

Reserves

2021		
Country	**tonnes Li**	**% world**
Chile	9,200,000	41.8
Australia	4,180,000	19.0
Argentina	2,200,000	10.0
China	1,500,000	6.8
USA	1,000,000	4.5
Congo	994,000	4.5
Mexico	849,000	3.9
Canada	550,000	2.5
Mali	364,000	1.7
Germany	304,000	1.4
Zimbabwe	234,000	1.1
Czech Republic*	274,000	1.3
Brasil	222,000	1.0
World	**22,000,000**	**100.0**

Source: MCS 2022 and own calculations
** Bilance zásob k 1. 1. 2022 (national Register of Reserves as of 1. 1. 2022)*

No reliable data are available to determine Rb and Cs reserves for specific countries. It is assumed that Australia, Canada, China, Namibia and Zimbabwe together have less than 200 kt Rb and 200 kt Cs (MCS 2021).

Li resources

2021			
Country	**tonnes Li**	**% world**	**% EU**
Svět celkem	108,415,000	100,0	-
EU	5,476,000	5.1	100.0
Německo	3,038,000	2.8	58.2
Česká republika	1,300,000	1.1	21.8
Španělsko	315,000	0.3	6.0
Finsko	308,000	0.3	5.9
Portugalsko	223,000	0.2	4.3
Francie	142,000	0.1	2.7
Rakousko	60,000	0.1	1.2

MCS 2022

Industrially important deposit types

1. Pegmatites and granites: Greenbushes (Australia), Manono (Congo, DR), Pilgangoora (Australia), Bikita (Zimbabwe)
2. Li – brines (Salars): Salar de Atacama (Chile), Salar de Uyuni (Bolivia), Quaidam Basin (China), Silver Peak (USA)
3. Li – brines (Geothermal and Oilfield Brines): Ortenau (Germany), Alberta (Canada)
4. Sedimentary: Sonora (Mexico), Jadar (Serbia), Thacker Pass (USA)

Uses

Production of electric batteries, cement, lubricants, pharmaceuticals, use in metallurgy (alloys), nuclear industry, glassmaking and ceramics.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – yes

Rubidium

Average Rb content (and its extent) in the earth's crust (ppm)

82 Rb

Industrially important minerals

Rubidium does not form its own minerals. It is contained in potassium feldspars (containing 3.3% of Rb_2O in some microclines), lepidolites (1–3.5% Rb_2O) and zinwaldites $K(Li,Fe,Al)_3(AlSi_3O_{10})(OH,F)_2$ (content = 1.5% Rb_2O)

Industrially important deposit types

1. Pegmatites and granites: Greenbushes (Australia), Tanco, Bernic Lake (Canada), Bikita (Zimbabwe)
2. Li – brines: Salar de Atacama (Chile), Salar de Uyuni (Bolivia), Quaidam Basin (China), Silver Peak (USA)
3. Magmatogenic phosphate deposits: Kola Peninsula (Russia)
4. Salt carnalite deposits: Kłodawa (Poland), Stassfurt (Germany), Ust-Vajviskoye, Verkhnekamskoye (Russia), Suria, Salena (Spain)

Reserves

No reliable data are available to determine Rb and Cs reserves for specific countries. It is assumed that Australia, Canada, China, Namibia and Zimbabwe together have less than 200 kt Rb and 200 kt Cs (MCS 2021).

The EU does not have Rb reserves.

Uses

Electronics, special glass, pharmacy, pyrotechnics

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

Cesium

Average Cs content (and its extent) in the earth's crust (ppm)

5 Cs

Industrially important minerals

It is part of several minerals with 5-32% of Cs_2O (e.g. lepidolite has 0.2–0.8% Cs_2O), only pollucite $Cs(AlSi_2O_6).H_2O$ (with up to 30% Cs_2O) is significant.

Industrially important deposit types

1. Pegmatites and granites: Greenbushes (Australia), Tanco, Bernic Lake (Canada), Bikita (Zimbabwe)
2. Li – brines: Salar de Atacama (Chile), Salar de Uyuni (Bolivia), Quaidam Basin (China), Silver Peak (USA)
3. Magmatogenic phosphate deposits: Kola Peninsula (Russia)

Reserves

No reliable data are available to determine Rb and Cs reserves for specific countries. It is assumed that Australia, Canada, China, Namibia and Zimbabwe together have less than 200 kt Rb and 200 kt Cs (MCS 2021).

The EU does not have Cs reserves.

Uses

Infrared detectors, photovoltaic cells, scintillation detectors, chemistry, radioisotopes, rocket fuels, insecticides, alkaline batteries, pyrotechnics, very dense flushing of subsea wells for oil and natural gas.

Classification as critical raw materials for the European Union

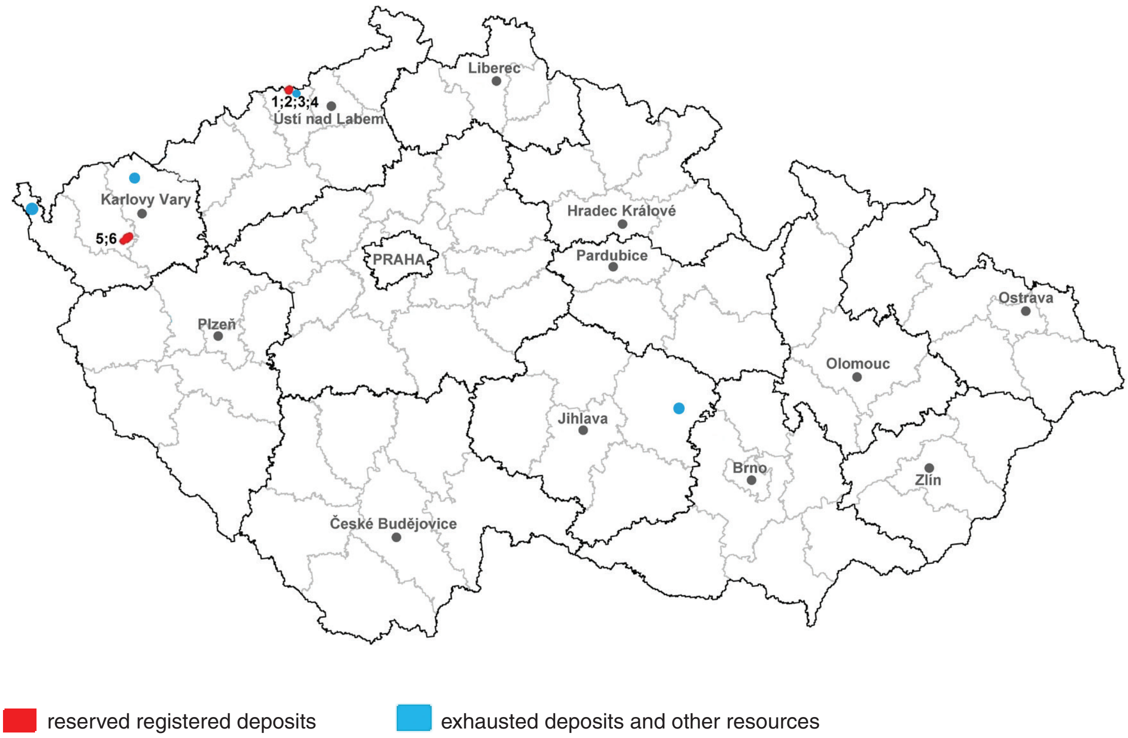
2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

In the Czech Republic, the entire Ore Mountains and the Slavkov Forest can be considered a lithium and rubidium province. Li raw materials are bound mainly to Li-mica, mainly zinnwaldite with a theoretical content of 1.4 to 1.6% Li, in bodies of greisen and greisenised granite associated with granitoid magmatism. With the exception of an unknown amount of mined lithium pegmatite in Rožná during World War II, Li ores were not mined separately in the Czech Republic. However, this changed in 2021, when open-pit mining of the Cínovec-odkaliště deposit began.

- Around 600–700 million tonnes of ores with increased Li contents were identified in the area of the Cínovec district in the eastern part of the Ore Mountains and its surroundings. At the three primary deposits of Li-Sn-W ores Cínovec-J, Cínovec-Z and Cínovec-V, the Register records 1,128 kt of lithium in 564 million tonnes of ore with an average content of 0.200% Li. In addition, the accompanying quantities of 806 kt Rb and 32 kt Cs were evaluated in the projected reserves at this deposit. Another 2.3 kt of Li are registered at the secondary deposit Cínovec-tailing pond, formed by waste material after treatment of Sn-W ores. Another similar deposit Horní Slavkov-tailing pond with 6.2 kt Li is registered in the Slavkov Forest. In addition, 2 kt of Li reserves and another 33–35 kt of Li are recorded in reserves in the Sn-W ore deposits in the primary deposits around Krásno and Horní Slavkov. However, the average Li contents in ores are lower (around 0.15% Li) than in the Cínovec district. In the western part of the Ore Mountains, the greisen zones are significantly smaller than the stocks and domes on the deposits and resources of the Cínovec and Krásno – Horní Slavkov districts, and there are no reserves or potentially promising Li resources.
- Smaller and insignificant resources are in pegmatites. The isolated former small deposit of Li-Sn ores Vernéřov near Aš is situated in the mica schist gneisses of the Ore Mountains crystalline complex in the western part of the Ore Mountains. 91 kt of ore resources with an average metal content of 0.56% Sn and 0.27% Li were evaluated, which corresponds to 530 t Sn and 249 t Li. Occurrences in the vicinity of Rožná are no longer of practical significance.
- Reources of brine with anomalous contents of bromine and lithium in the amount of 453.6 million m³ were evaluated in the mining lease of the Slaný bituminous coal deposit. These resources of ground mineralised water contain 123 kt Br, 15 kt Li and more than 18 million t NaCl.

3. Registered deposits and other resources of the Czech Republic



The registered deposit are not exploited

*(Name of area with exploited deposit is in **bold**)*

1 Cínovec-jih*	3 Cínovec-východ	5 Horní Slavkov-odkaliště
2 **Cínovec odkaliště**	4 Cínovec-východ	6 Krásno-Koník

Note:

** Deposit of also potentially economic reserves of Sn-W ores and contents of Ta and Nb in experimental concentrates*

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2017	2018	2019	2020	2021
Deposits – total number	5	6	6	6	6
Exploited	0	0	0	0	1
Total *reserves, t Li	454,577	1,138 331	1,138,331	1,138,331	1,138,331
economic explored reserves	52,283	156,239	156,239	156,239	156,239
economic prospected reserves	72,490	118,542	118,542	118,542	118,542
potentially economic reserves	329,804	863 550	863,550	863,550	863,550
Mine production, t Li	0	0	0	0	0,7

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic and its evolutional comparison with international classifications** of this yearbook*

In the Czech Republic, it is possible to consider the entire Krušné hory Mts. as a lithium province. Around 300 million tonnes of ore with elevated lithium contents were identified in Cínovec and its surroundings alone. As for the potentially economic deposit of tin-tungsten ores of Cínovec-jih, 159,993 tonnes of lithium in 53.4 million tonnes of ore with an average lithium content of 0.117% are recorded in the Register of reserved mineral deposits of the Czech Republic. In addition, byproduct amounts of 56 kt of rubidium and 1.8 kt of cesium were also evaluated in this deposit. Beside the Register of reserved mineral deposits of the Czech Republic Li reserves are estimated also at former deposits Cínovec-sever-lomová těžba (79 kt), Cínovec-starý závod (3.8 kt), Vernéřov u Aše (15.2 kt) and Krásno-Koník (2 kt).

Brine reserves with anomalous bromine and lithium contents were calculated at 453.6 million m^3 in the mining lease of the Slaný deposit of bituminous coal. These groundwater reserves contain 123 kt of bromine, 15 kt of lithium and more than 18 million tonnes of NaCl.

Approved prognostic resources P_1, P_2, P_3
Li in ore

Year		2017	2018	2019	2020	2021
P_1,	t	2 142	2 142	2 142	2 142	2 142
P_2		–	–	–	–	–
P_3		–	–	–	–	–

5. Foreign trade

280519 – Lithium, potassium, rubidium, cesium

		2017	2018	2019	2020	2021
Import	kg	8,250	41,993	29,124	71,432	41,283
Export	kg	500	601	87	28	109

280519 – Lithium, potassium, rubidium, cesium

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	1,387	489	757	294	524
Average export prices	CZK/kg	18	241	184	179	8 303

28369100 – Lithium carbonates

		2017	2018	2019	2020	2021
Import	kg	362,598	65,937	76,403	46,981	101,644
Export	kg	3,798	7,495	3,402	2,886	5,537

28369100 – Lithium carbonates

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	90	358	313	191	265
Average export prices	CZK/kg	32	245	266	139	32

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World production

World lithium production has been growing for a long time in connection with the increase in the use of lithium in the battery industry. The largest increase occurred between 2016 and 2018, when world production doubled. There is no reliable information on world rubidium production, the raw material is probably obtained in Namibia, Zimbabwe and China, but the total production volume is unknown. Small quantities of cesium are also obtained in Namibia and Zimbabwe as a by-product of lithium mining.

Commodity/year	2017	2018	2019	2020	2021[e]
World mine production of lithium (according to MCS), t	69,000	95,000	86,000	82,500	100,000
World mine production of Li_2O (according to WBD), t	162,333	198,464	189,180	185,850	N

e – preliminary value

Data on rubidium and cesium mining are not provided.

Main producers according to MCS

Country	2021[e]	
	t	%
Australia	55,000	52.6
Chile	26,000	24.9
China	14,000	13.3
Argentina	6,200	5.9
Brasil	1,500	1.3
Zimbabwe	1,200	1.2
Portugal	900	0.9
World	**104,000**	**100.0**

e – preliminary values

The world's largest lithium miners / producers

1. Jiangxi Ganfeng Lithium
2. Mineral Resources
3. Pilbara Minerals
4. Albemarle Corporation
5. Sichuan Tianqi Lithium
6. Sociedad Química y Minera de Chile (SQM)
7. Allkem
8. Livent Corporation
9. Companhia Brasileira de Lítio
10. Bikita Minerals

Prices of traded commodities containing lithium according to IM

Commodity/year		2017	2018	2019	2020	2021[e]
Lithium carbonate, battery quality, annual average (according to MCS)	USD/t	15,000	17,000	12,700	8,000	17,000

e - předběžné údaje

Prices of sold commodities containing rubidium and cesium in the USA – MCS data quotation

In 2020 2021, one company offered 1 gram ampoule of 99.75% rubidium (metal-based) for $ 93.40, a small increase from $ 89.00 in 2020 and 100 gram ampoules of the same material for $ 1,673.00, a small increase from $ 1,608.00 in 2020. The price per gram of 99.8% rubidium formate hydrate (metal base) was $ 262.

In 2021, prices per 10 grams of 99.8% (metal-based) rubidium acetate, rubidium bromide, rubidium carbonate, rubidium chloride and rubidium nitrate were $ 51.40, $ 71.20, $ 54.80, $ 62.70 and $ 48.50 USD. The price for a standard rubidium-plasma solution (10,000 micrograms per milliliter) was $ 57.70 per 50 milliliters and $ 93.70 per 100 ml – increase by 17% respectively 16% compared to 2020.

In 2021, one company offered 1 gram ampoule of 99.8% (metal-based) cesium for $ 69.90, an increase of 7.2% from $ 65.20 in 2020 and 99.98% (metal-based).) cesium for $ 88.90, an increase of 5.0% from $ 84.70 in 2020.

In 2021, prices per 50 grams of 99.9% (metal base) cesium acetate, cesium bromide, cesium carbonate, cesium chloride and cesium iodide were $ 131.20, $ 75.90, $ 110.20, $ 112.00 and $ 127.60, an increase of between 4.1 and 9.3% compared to 2020. Prices of the standard cesium-plasma solution (10,000 micrograms per milliliter) were $ 78.60 per 50 milliliters and $ 120.00 per 100 milliliters and the price per 25 grams of cesium formate, 98%, was $ 42.60.

Molybdenum

1. Characteristics and use

Average Mo content (and its extent) in the earth's crust (ppm)

1.5 Mo

Industrially important minerals

Molybdenite MoS_2 (60% Mo), wulfenite $PbMoO_4$ (26% No), powellite $CaMoO_4$ (48% Mo)

Industrially important deposit types

1. Copper deposits in porphyries: Climax (USA), Henderson (USA), Questa (USA), El Teniente (Chile), Umalta (Russia), Zhireken (Russia), Karatas (Kazakhstan), Jinduicheng (China), Quishuwan (China), Yulong (China)
2. Uranium infiltration deposits in sandstones: Akouta (Nigeria)

Reserves

2021		
Country	**kt**	**% world**
China	8,300	51.7
USA	2,700	16.8
Peru	2,300	14.3
Chile	1,400	8.7
Russia	430	2.7
Turkey	360	2.2
Armenia	150	0.9
Mexico	150	0.8
Argentina	100	0.6
Canada	96	0.6
Uzbekistan	60	0.4
Iran	43	0.3
World	**16,000**	**100.0**

Source: MCS 2022

Uses

Alloying of steel, cast iron and superalloys. Due to its heat resistance, the metal is used in many chemical applications, including catalysts, lubricants and pigments.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved prognostic resources of molybdenum. At the Hůrky locality in the Čistá-Jesenice Massif, prognostic resources of Mo ores are estimated at 18,327 t of Mo.

3. Registered deposits and other resources of the Czech Republic

In the Czech Republic, 80 million tonnes of prognostic resources (unapproved) of molybdenum ores with an average molybdenum content of 0.176 %, i.e. 18,327 tonnes of molybdenum, were estimated in the Hůrky locality in the Čistá-Jeseník Massif (L. Kopecký 1983) and at the graphite deposit Bližná in the Bohemian Forest Foothils 52 tonnes of Mo have been estimated.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

81029400 – Unwrought molybdenum, including bars, rods obtained by simple sintering

		2017	2018	2019	2020	2021
Import	kg	3	1,880	11,451	548	2,065
Export	kg	7,215	3,633	13,785	10,171	9,563

81029400 – Unwrought molybdenum, including bars, rods obtained by simple sintering

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	6,000	513	854	449	836
Average export prices	CZK/kg	584	737	799	740	637

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

According to statistics, world production of primary molybdenum developed as follows during 2016–2020:

	2017	2018	2019	2020	2021e
World mine production of molybdenum (according to COCHILCO), kt	293	274	278	291	269
World mine production of molybdenum (according to MCS), kt	297	297	294	298	300
World mine production of molybdenum (according to WBD), kt	285	270	277	284	N

e – preliminary values;

COCHILCO – (Comisión Chilena del Cobre)

Main producers according to COCHILCO

Country	2021e	
	t	%
China	95,300	35.4
Chile	49,400	18.4
USA	40,500	15.1
Peru	34,100	12.7
Mexico	18,900	7.0
Arménie	11,300	4.2
Russia	10,800	4.0
Iran	3,100	1.2
Mongolia	3,000	1.1
Canada	1,400	0.5
World	**268,800**	**100.0**

e – předběžné údaje

Main producers according to MCS

Country	2021e	
	t	%
China	130,000	43.8
Chile	51,400	17.3
USA	48,000	16.2
Peru	32,000	10.8
Mexico	18,000	6.1
Armenia	8,200	2.8
Mongolia	2,900	1.0
Russia	2,800	0.9
Canada	1,700	0.6
Iran	1,400	0.5
South Korea	400	0.1
Uzbekistan	200	0.1
World (rounded)	**300,000**	**100.0**

e – předběžné údaje

Prices of traded commodities

World Mo commodity prices (USD/kg Mo) developed according to DERA yearbooks, Mineral Commodity Summaries (MCS):

Commodity/Year	2017	2018	2019	2020	2021
Ferromolybdenum, 65–70% Mo base, free European market (USD/kg) (according to DERA)	15.81*	29.00	26.55	21.30	37.02
Molybdenum, annual average (according to MCS) USD/kg	18.06	27.04	26.50	19.90	36.00
Molybdenum, LME cash** (according to DERA), (USD/t)	15,000–15,250	24,000–30,350	40,100	38,000	49,200

* *Engeneering&Mining Journal: average of 12 monthly quotations*

** *The price range of molybdenum includes the lowest and highest monthly price quotes for a given year.*

Rare earths

A total of 16 elements belong to the group of rare earths. They can be divided into two subgroups or series. The yttrium series (also referred to as Heavy Rare Earths Elements – HREE) includes yttrium (y), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb) and lutetium (Lu). The cerium subgroup (also referred to as Light Rare Earths Elements – LREE) includes cerium (Ce), lanthanum (La), praseodymium (Pr), neodymium (Nd), promethium (Pm) and samarium (Sm). Sometimes scandium (Sc) is also considered a rare earth element. Rare earth elements are also collectively referred to as lanthanides (Ln) or terrae rarae (TR) or rare earths elements (REE). Sometimes yttrium is not considered a rare earth, as is the case with scandium, other times it is possible to find a definition that rare earths REE is the collective name for 17 chemically similar metal elements – lanthanides, scandium and yttrium.

1. Characteristics and use

Average content (and its extent) in the earth's crust (ppm)

22 Sc, 33 Y, 29 La, 66.5 Ce, 9.2 Pr, 41.5 Nd, 10^{-15} Pm, 7.05 Sm, 2 Eu, 6.2 Gd, 1.2 Tb, 5.2 Dy, 1.3 Ho, 3.5 Er, 0.52 Tm, 3.2 Yb, 0.8 Lu

Industrially important minerals

Monazite $(Ce,La,Y,Nd,Sm,Th)PO_4$ (65% of rare earth oxides), bastnäsite $(Ce,La,Y)CO_3(F,OH)$ (75% of rare earth oxides), xenotime $Y(HREE)PO_4$ (61% of rare earth oxides), loparite $(Ce,Th,Na,Ca)_2(Ti,Nb)_2O_6$ (36% of rare earth oxides); a number of minerals are often REE carriers such as zircon, wolframite, scheelite, apatite, alanite.

Industrially important deposit types

Rare earths occur and are obtained mainly as by-products and co-products of a number of genetic types of deposits. Simplified:

1. Pegmatite, skarn: Kola Peninsula (Russia), Mary Kathleen (Australia),
2. Magmatic-hydrothermal, metasomatic: Olympic Dam (Australia)
3. Magmatic-hydrothermal, metasomatic with carbonatites: Mountain Pass (USA), Bayan Obo (China), Palabora (South Africa), Araxá (Brazil)
4. Volcanogenic-hydrothermal: Gallinas Mountains (USA)
5. Residual: Mrima Hill (Kenya), Araxá (Brazil), Mount Weld (Australia), Xunwu, Longnan (China)
6. Placer: Coastal marine placers with monazite and xenotime – coast of Australia, India (most important producer of monazite), Malaysia (largest miner of xenotime), Sri Lanka, Brazil.

The EU does not have rare earths reserves. (European Minerals Yearbook – version 2021).

Reserves

2021		
Country	**t***	**% world**
China	44,000,000	35.3
Vietnam	22,000,000	17.6
Brazil	21,000,000	16.8
Russia	21,000,000	16.8
India	6,900,000	5.5
Australia	4,000,000	3.2
USA	1,800,000	1.4
Greenland	1,500,000	1.2
Tanzania	890,000	0.7
Canada	830,000	0.70
South Africa	790,000	0.6
World	**120,000,000**	**100.0**

Source: MCS 2022
** recalculated to REO content (Rare Earths Oxides)*

Uses

Rare earth compounds add new, often unusual properties to many materials, even in small admixtures. At the beginning of the 21st century, the majority of REE cerium oxides were consumed worldwide in glass cutting and ceramics. REE compounds are further used in automotive catalysts as well as in oil refining as catalysts and in the chemical industry in general. REE compounds are widely used in metallurgy. REEs are used in the production of television and computer monitors, in lighting and radar technology, etc. The production of highly efficient permanent magnets is not conceivable today without samarium compounds or other REEs (Tb, Dy). Many applications have a significant overlap in military production and REEs have an enhanced strategic importance.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved sources of REE.

3. Registered deposits and other resources of the Czech Republic

In the Czech Republic, there are descriptions of estimated resources (unapproved) of rare earth oxidees from various mineralisations and geological formations. For example, the cerium content in uranium ores of uranium-bearing sandstone of the Stráž block in the Bohemian

Cretaceous Basin was evaluated at 4,750 tonnes of cerium. 23.6 t of yttriumoccur at the Bližná v Pošumaví graphite deposit, together with 49 t of REEs in total. There is also an unapproved source of 2 t Sc in the Krásno locality. The tailing pond in Stráž pod Ralskem, where leachate waste from the deposit containing 0.030 to 0.063% of rare earths (lanthanum to gadolinium) has accumulated for decades, but also scandium, yttrium, niobium, zirconium and hafnium is a potential source of these metals. Anomalous rare earth oxide contents are also assumed to occur in the Hůrky locality in the Čistá-Jesenice Massif (along with resources of Mo, Ta, Nb, Zr, and Hf), in alkaline volcanic rocks in the České Středohoří, in volcanic rocks of the Šternberk-Horní Benešov belt in the Nízký Jeseník Mts., in graphitic phyllites of the Železné Hory Mts. Proterozoic, in argillitised tuffs of the Upper Silesian Basin etc.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

28461000 – Cerium compounds

		2017	2018	2019	2020	2021
Import	kg	76,259	54,386	49,911	30,306	34,186
Export	kg	3,639	6,167	3,570	3,027	3,427

28461000 – Cerium compounds

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	251	546	472	450	442
Average export prices	CZK/kg	32	595	551	568	580

28053010 – Rare earth metals, scandium and yttrium, intermixed or interalloyed

		2017	2018	2019	2020	2021
Import	kg	3 931	561	711	716	1,175
Export	kg	330	0	0	0	0

28053010 – Rare earth metals, scandium and yttrium, intermixed or interalloyed

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	476	282	215	159	178
Average export prices	CZK/kg	400	–	–	–	–

28053090 – Rare earth metals, scandium and yttrium, not intermixed or interalloyed

		2017	2018	2019	2020	2021
Import	kg	0	0	0	0	0
Export	kg	0	0	0	0	0

28053090 – Rare earth metals, scandium and yttrium, not intermixed or interalloyed

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

Statistical data on world production of rare earths for the past five years:

	2017	2018	2019	2020	2021^{e}
World mine production, t (according to MCS)	132,000	190,000	220,000	240,000	280,000
World production of concentrates, t (according to WBD)	134,521	181,584	202,315	225,277	N

e – preliminary values

Main producers of rare earths according to WBD

Country	2020	
	t	%
China	140,000	62.8
USA	39,000	17.5
Australia	21,000	9.4
Myanmar	17,100	7.7
Russia	2,663	1.2
India	2,100	0.9
Brazil	708	0.3
Burundi	296	0.1
World	**225,277**	**100.0**

Main producers of rare earths according to MCS

Country	2021e	
	t	%
China	168,000	60.9
USA	43,000	15.6
Burma	26,000	9.4
Australia	22,000	8.0
Thailand	8,000	2.9
Madagascar	3,200	1.2
India	2,900	1.1
Russia	2,700	1.0
World	**280,000**	**100.0**

e – preliminary values

According to MCS estimate, 8,000 – 12,000 tonnes yearly of Y_2O_3 were produced worldwide in present years. Most of the production comes from China and Burma.

Prices of rare earth oxides (USD/kg) according to the Mineral Commodity Summaries

Commodity/year		2017	2018	2019*	2020	2021
Rare earth oxidees, USD/kg	Ce 99,5% min.	2	2	2	2	2
	Dy 99,5% min.	187	179	179	261	400
	Eu 9,99% min.	77	53	53	31	31
	La 99,5% min.	2	2	2	2	2
	Nd 99,5% min.	50	50	50	49	49
	Eu 9,99% min.	501	455	455	670	1,300

Prices of traded commodities

According to DERA world prices (USD/kg) of commodities with rare earths developed as follows in recent years:

	2017	2018	2019	2020	2021
Cerium oxide. 99%. bulk. FOB China	2.00	2.00	1.90	1.70	1.49
Dysprosium (metal), min 99 %, FOB China	N	261.97	307.02	340.10	518.12
Dysprosium (oxide), min. 99 %, FOB China	N	177.41	234.33	259.10	405.83
Erbium (oxide), min. 99 %, FOB China	N	24.66	23.96	22.50	35.60
Europium (oxide), min. 99 %, FOB China	N	51.32	34.61	29.80	31.86
Lanthanum (oxide) min. 99 %, FOB China	N	0	1.88	1.60	1.47
Lanthanum (oxide), min- 99,999 %, FOB China	N	3.53	3.41	3.30	3.89
Neodymium (metal), min. 99 %, FOB China	N	63.72	57.52	61.50	120.80
Neodymium (oxide), min. 99 %, FOB China	N	49.92	45.24	48.70	98.43
Praseodymium (metal), min. 99 %, FOB China	N	114.48	102.64	91.30	112.23
Praseodymium (oxide), min. 99 %, FOB Europe	N	67.21	53.41	43.50	79.24
Praseodymium (oxide), min. 99 %, FOB China	N	63.63	54.32	45.70	92.27
Samarium (metal), min. 99 %, FOB China	N	14.88	13.87	13.10	13.94
Samarium (oxide), min. 99 %, FOB China	N	2.14	1.83	1.80	2.22
Scandium (oxide), min. 99,5 %, FOB China	N	7,025.44	7,025.24	6,386.10	5,755
Terbium (metal), min. 99 %, FOB China	N	604.25	657.57	848.80	1,681.75
Terbium (oxide), min. 99,9 %, FOB China	N	454.83	506.34	663.90	1,322.33
Yttrium (metal), min. 99 %, FOB China	34.79	N	35.24	31.03	28.60
Yttrium (oxide), min. 99,999 %, FOB China	3.67	N	3.21	2.99	2.90

Selenium, tellurium

1. Characteristics and use

Selenium and tellurium are elements with chemical properties and affinity close to sulphur.

Selenium

Average Se content (and its extent) in the earth's crust (ppm)

0.09 Se

Industrially important minerals

Clausthalite PbSe, ferroselite $FeSe_2$ and berzelianite $Cu_{1-9}Se$. Se is in a lattice of sulphide minerals.

Industrially important deposit types

Selenium is obtained as a by-product from polymetallic deposits and deposits of copper and nickel. Selenium is often separated from sulphur by geological processes and is enriched, for example, in some stratiform uranium deposits (Colorado Plateau, USA).

Reserves

2021		
Country	**t**	**% world**
China	26,000	26.0
Russia	20,000	20.0
Peru	13,000	13.0
USA	10,000	10.0
Canada	6,000	6.0
Poland	3,000	3.0
World	**100,000**	**100.0**

Source: MCS 2022

The EU does not report selenium reserves with the exception of Poland which has 3 kt Se. i.e. 3% of world reserves (MCS 2022, European Minerals Yearbook – version 2022).

Uses

Selenium is used in glass production for decolourising bottle glass, in chemistry and paint production, in electronics and in other industries, including agriculture. Tellurium is used mainly as an additive in the production of engineering steels, in catalysts and chemical production, as an additive in non-ferrous alloys, as a photoreceptor and in thermoelectric devices.

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – no, 2020 – no

Tellurium
Average Te content (and its extent) in the earth's crust (ppm)
0.002 Te

Industrially important minerals
Hessite Ag_2Te, nagyágite $[Pb(Pb,Sb)]S_2][Te.Au]$, sylvanite $AuAgTe_4$ and tetradymite Bi_2Te_2S

Industrially important deposit types
Tellurium is obtained as a by-product, mainly from copper deposits. It also occurs in polymetallic deposits, nickel deposits and some gold deposits (Roşia Montană, Romania, Kalgoorlie, Australia, Comstock, USA).

Reserves

2021		
Country	**t**	**% world**
China	6 600	21.3
USA	3 500	11.3
Canada	800	2.6
Sweden	670	2.2
World	**31 000**	**100.0**

Source: MCS 2022

In the EU, reserves are reported for Sweden only, approximately 600 t Te, thus 0.2% of the world's Te reserves (MCS 2022, European Minerals Yearbook – version 2022).

Uses
Tellurium is used mainly as an additive in the production of engineering steels, in catalysts and chemical production, as an additive in non-ferrous alloys, as a photoreceptor and in thermoelectric devices.

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic
The Czech Republic does not have any approved resources of tellurium. It has an unapproved resource of selenium in the Zlaté Hory district.

3. Registered deposits and other resources of the Czech Republic

In the Czech Republic unapproved prognostic resources of Se, in the Zn-Pb-Cu deposit Zlaté Hory-západ, were evaluated tentatively at more than 13 tonnes (K.Stuchlíková – I.Frolíková 1988).

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

280490 – Selenium

		2017	2018	2019	2020	2021
Import	kg	6,458	7,927	4,454	7,153	5,181
Export	kg	1	3	28	16	6

280490 – Selenium

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	881	810	537	449	399
Average export prices	CZK/kg	17,000	4,333	4,000	3,750	7,833

28045090 – Tellurium

		2017	2018	2019	2020	2021
Import	kg	1	89	153	9	4
Export	kg	0	0	0	0	0

28045090 – Tellurium

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	7,000	8,803	4,320	8,000	7,250
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

Statistical data on selenium and tellurium production have been updated only in recent years. The following are data from the Mineral Commodity Summaries (MCS) and Welt Bergbau Daten (WBD):

	2017	2018	2019	2020	2021
World production of selenium according to MCS, t	2,710	2,810	2,880	3,120	3,000
World production of selenium according to WBD, t	3,006	3,199	3,537	3,334	N
World production of tellurium according to MCS, t	470	460	520	562	580
World production of tellurium according to WBD, t	613	649	529	444	N

Since selenium and telur represent a byproduct in the processing of copper ores, information on production and resources is derived from the situation on Cu ore deposits.The current situation in the production of both metals and the world's major producers are presented in the following tables:

Main producers of selenium according to WBD

Country	2020	
	t	%
China	1,120	36.52
Japan	740	24.13
Germany	300	9.78
Belgium	200	6.52
Russia	193	6.29
USA	150	4.89
Mexico	106	3.46
Philippines	100	3.26
Finland	84	2.74
Poland	74	2.41
World	**3,334**	**100.00**

Main producers of selenium according to MCS

Country	2021e	
	t	%
China	1,100	37.61
Japan	750	25.64
Germany	300	10.26
Russia	300	10.26
Belgium	200	6.84
Finland	100	3.42
Poland	65	2.22
Canada	60	2.05
Turkey	50	1.71
World	**3,000**	**100.00**

e – preliminary values

Main producers of tellurium according to WBD

Country	2020	
	t	%
China	260	58.96
Japan	70	15.87
Sweden	42	9.52
Canada	23	5.22
Russia	40	9.07
Bulgaria	4	0.91
USA	2	0.45
World	**604**	**100.00**

Main producers of tellurium according to MCS

Country	2021[e]	
	t	%
China	340	58.82
Japan	75	12.98
Russia	70	12.11
Canada	45	7.79
Sweden	40	6.92
Bulgaria	5	0.87
South Africa	3	0.52
World	**490**	**100.00**

Prices of global commodities

According to DERA yearbooks for 2017–2021 the average world prices of selenium and tellurium (USD/kg) were as follows:

Commodity/year	2017	2018	2019	2020	2021
Selenium, powder, min. 99.5%,	37.83	37.89	21.42	15.70	22.87
Tellurium, min. 99.99%, Europe	40.42	66.35	63.52	61.50	78.16

Average prices of selenium and tellurium (USD/kg) in the USA (MCS) were as follows:

Commodity/year	2017	2018	2019	2020	2021[e]
Selenium metal, powder, min. 99.5%, FOB warehouse U.S.	15.55	16.85	9.15	6.61	8.00
Tellurium, avg.ann.price, 99.95%, warehouse Rotterdam	38	74	60	56	68

e – preliminary values

Tantalum, niobium

Tantalum and niobium are chemically related elements that occur in nature together. They are concentrated in nature in the late phase of magma crystallisation, most often in pegmatites and also in carbonatites.

1. Characteristics and use

Tantalum

Average Ta content (and its extent) in the earth's crust (ppm)
2.1 Ta

Industrially important minerals
Tantalite $FeTa_2O_6$ (40–81% Ta_2O_5), pyrochlore $NaCaNb_2O_6F$ (0.2–39% Ta_2O_5), microlith $NaCaTa_2O_6F$ (max. 80% Ta_2O_5), wodginite $MnSnTa_2O_8$ (70.5% Ta_2O_5)

Industrially important deposit types
1. Primary deposits in igneous rocks such as carbonatites, pegmatites and nepheline syenites: Araxá (Brazil), Chibiny (Russia), Tanco (Canada), Dajishan and Limu (China).
2. Placers of stable minerals such as columbite, tantalite, pyrochlore: Bukuru (Jos Plato, Nigeria), Ngulla (Tanzania), Mtoko (Zimbabwe)

Reserves

2021		
Country	**t**	**% world**
Australia	94,000	7
Brazil	4,000	3
World	**>140,000**	**100.0**

Source: MCS 2022

The EU does not have tantalum reserves.

Uses
Tantalum is mostly used in electronics, especially in tantalum capacitors in computer technology and in mobile phones. It is also used in the production of superalloys for aircraft engines and metalworking tools.

Classification as critical raw materials for the European Union
2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes

Niobium

Average Nb content (and its extent) in the earth's crust (ppm)

20 Nb

Industrially important minerals

Pyrochlore $NaCaNb_2O_6F$ (40–72% Nb_2O_5), columbite $FeNb_2O_6$ (40–77% Nb_2O_5) a loparite $NaCe(Ti,Nb)_2O_6$ (8–13% Nb_2O_5)

Industrially important deposit types

1. Primary deposits in igneous rocks such as carbonatites, pegmatites and nepheline syenites: Araxá (Brazil), Chibiny (Russia), Tanco (Canada), Dajishan and Limu (China).
2. Placers of stable minerals such as columbite, tantalite, pyrochlore: Bukuru (Jos Plato, Nigeria), Ngulla (Tanzania), Mtoko (Zimbabwe).

Reserves

The EU does not have niobium reserves.

2021		
Country	**t**	**% world**
Brazil	16 000 000	< 88,9
Canada	1 600 000	< 10,0
USA	170 000	< 0,9
World	**> 18 000 000**	**100,0**

Source: MCS 2022

Uses

The main consumption of niobium goes to the production of ferroniobium for the steel industry and niobium superalloys for the rocket and aerospace industries.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved sources of Ta and Nb.

3. Registered deposits and other resources of the Czech Republic

IIn the Czech Republic, prognostic resources (unapproved) were evaluated at 3,238 tonnes in uranium deposits and uranium-bearing sandstone of the Stráž block in the Bohemian Cretaceous Basin (along with TR, Zr and Hf), and another 568 tonnes in the Hůrky locality in the Čistá-Jeseník Massif (along with Mo, TR, Zr and Hf), where 57 tonnes of prognostic tantalum resources were also calculated. In the Krásno and Cínovec area 13,670 t Ta and 19,702 t Nb of prognostic (unapproved) resources were enumerated. Recoverable contents of tantalum and niobium are also known to occur in tungsten and tin concentrates, which were recovered experimentally during the exploration of the tin-tungsten ore deposit of Cínovec-jih (along with Li, Rb and Cs).

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

26159010 – Tantalum and niobium ores and concentrates

		2017	2018	2019	2020	2021
Import	kg	14,411	11,293	–	–	11,428
Export	kg	27,714	–	1,451	–	14,829

26159010 – Tantalum and niobium ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	781	851	–	–	784
Average export prices	CZK/kg	1,030	–	1,147	–	1,158

810320 – Unwrought tantalum

		2017	2018	2019	2020	2021
Import	kg	109,479	128,135	110,953	40,531	13,390
Export	kg	86,095	22,702	19,018	28,400	80,597

810320 – Unwrought tantalum

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	6,249	6,429	5,445	5,497	7,254
Average export prices	CZK/kg	9,362	9,681	8,849	11,425	9,124

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

World production of tantalum and niobium in 2017–20121:

	2017	2018	2019	2020	2021^e
World production of tantalum (according to MCS) t	1,810	1,890	1,850	2,100	2,100
World production of niobium (according to MCS) t	69,100	68,200	97,000	67,700	75,000

e – preliminary values

	2017	2018	2019	2020	2021
World production of tantalum (according to WBD), t Ta_2O_5	1,775	2,263	2,006	1,611	1,682
World production of niobium (according to WBD), t Nb_2O_5	88,564	91,980	109,023	135,539	93,509

Main producers of Ta according to WBD

Country	2020	
	t	%
Congo Kinshasa)	600	35.7
Brazil	300	17.8
Rwanda	240	14.3
China	180	10.7
Nigeria	100	5.9
Mozambique	94	5.6
Russia	60	3.6
Australia	50	3.0
Ethiopia	41	2.4
Malaysia	2	0.1
World	**1,682**	**100.0**

Main producers of Ta according to MCS

Country	2021^e	
	t	%
Congo (Kinshasa)	700	33.3
Brazil	470	22.4
Rwanda	270	12.9
Nigeria	260	12.4
China	76	3.6
Australia	62	3.0
Ethiopia	52	2.5
Mozambique	43	2.0
World	**2,100**	**100.0**

e – preliminary values

Main producers of Nb according to WBD

Country	2020	
	t	%
Brazil	85,572	91.5
Canada	6,400	6.8
Russia	617	0.7
Congo (Kinshasa)	565	0.6
Rwanda	160	0.2
Nigeria	80	0.1
China	30	0.0
Mozambique	17	0.0
Ethiopia	11	0.0
World	**93,509**	**100.0**

Main producers of Nb according to MCS

Country	2021[e]	
	t	%
Brazil	66,000	88.0
Canada	7,400	9.9
World	**75,000**	**100.0**

e –preliminary values

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021
Niobium metal (USD/kg)*	41,950	42,280	N	N	N
Tantalum metal (USD/t)*	128,000	151,800	N	N	N
Tantalite, dollars per kilogram of Ta_2O_5 content (MCS)	193.00	214.00	161.00	158.00	158.00
Ta conc. 30 % Ta_2O_5, CIF China, USD/kgs (according to DERA)	N	203.03	139.55	131.90	155.84
Ta pentoxide, min. 99,5 %, FOB China, USD/kg (according to DERA)	N	271.53	194.34	184.90	209.29
Nb conc. min. 50 % Nb_2O_5, min. 5% Nb_2O_5, CIF China, USD/kg (according to DERA)	N	35.41	22.93	20.90	27.01
Nb pentoxide, 99,5 %, FOB China USD/kg (according to DERA)	N	42.46	33.34	29.40	34.64
Feroniobium, imports and exports to the USA, USD/kg (according to MCS)	20.00	21.00	23.00	24.00	20.00

* *According to Metalary data (https://www.metalary.com/tantalum-price/ and https://www.metalary.com/niobium-price/)*

Zirconium, hafnium

Chemically, zirconium and hafnium have the same behaviour and occur together. Individual Hf minerals are not known. A constant Zr/Hf ratio of 50:1 is typical for ore occurrences of both elements.

1. Characteristics and use

Average Zr and Hf content (and its extent) in the earth's crust (ppm)

160 (130–400) Zr, 3 Hf

Industrially important minerals

Baddeleyite ZrO_2 (94% ZrO_2, 1.5–4% Hf), zircon $ZrSiO_4$ (67% Zr, 1.5–4% Hf)

Industrially important deposit types

1. Primary ores consisting of baddeleyite in carbonatites and nepheline syenites with apatite: Kovdor (Russia), Palabora (South Africa), Jacupiranga (Brazil).
2. Placers of zircon sands, most often of the beach type: East Australian coast (Murray Basin), Ukraine, Brazil, India, South Africa (Richards Bay).

Reserves

Zirconium

2021		
Country	**kt**	**% world**
Australia	50,000	71.4
South Africa	5,900	8.4
Mozambique	1,800	2.6
Canada	500	0.7
USA	500	0.7
Kenya	50	0.1
World	**70,000**	**100.0**

Source: MCS 2022

The EU does not have zirconium reserves. (European Minerals Yearbook – version 2021)

Hafnium

The world's hafnium reserves are unknown but with the help of the known ratio Zr/ZrO_2 = 91/123 and the ratio Zr/Hf in zirconium = 33–50/1 it can be estimated that world reserves of Hf range from 950 to 1,430 kt. The EU does not have hafnium reserves (European Minerals Yearbook – version 2021).

Uses

Zircon is used mainly in the ceramic and glass industries, in the production of refractory materials and in the manufacture of moulds in foundries. Other areas of Zr application include abrasives, the production of chemicals, metal alloys, protective coatings for welding electrodes and the production of blasting sands. The largest share of hafnium goes to the production of superalloys for the needs of the nuclear energy and chemical industries.

Classification as critical raw materials for the European Union

Zr: 2011 – no, 2014 – no, 2017 – no, 2020 – no
Hf: 2011 – no, 2014 – no, 2017 – yes, 2020 – yes

2. Mineral resources of the Czech Republic

In the Czech Republic, there are unapproved prognostic resources of zirconium and hafnium in uranium bearing sandstone ores and in fenites of Čistá-Jesenice Massif.

3. Registered deposits and other resources of the Czech Republic

In the Czech Republic, prognostic resources of zirconium and hafnium in uranium deposits of uranium-bearing sandstone of the Stráž block in the Bohemian Cretaceous Basin (along with TR, Ta, Nb) were estimated at 285,416 tonnes of zirconium. Assuming a Zr/H ratio in zircon = 33–50/1, the amount of accompanying hafnium can be estimated at 5,700–8,600 tonnes. Another 122,370 tonnes of zirconium and 2,446 tonnes of hafnium are assumed to occur in fenites in the Hůrky locality in the Čistá-Jesenice Massif (along with Mo, TR, Ta, Nb). All the resources are unapproved.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

26151000 – Zirconium ores and concentrates

		2017	2018	2019	2020	2021
Import	kg	612,117	596,784	566,118	0	0
Export	kg	4,400	6,170	4,265	0	0

26151000 – Zirconium ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	40	43	49	–	–
Average export prices	CZK/kg	22	40	46	–	–

81129210 – Unwrought hafnium, hafnium waste and scrap, hafnium powders

		2017	2018	2019	2020	2021
Import	kg	2	1	1	18	17
Export	kg	0	0	0	0	0

81129210 – Unwrought hafnium, hafnium waste and scrap, hafnium powders

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	23,000	12,000	9,000	33,000	37,706
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production

Statistical data on zirconium production

	2017	2018	2019	2020	2021^e
World production, kt (according to MCS)*	1,550	1,480	1,420	1,200	1,200
World production, kt (according to WBD)	1,379	1,569	1,386	1,236	N

e – preliminary values

** Zr concentrates*

Main producers according to MCS-Zr concentrates

Country	2021^{e}	
	t	%
Australia	400	33.3
South Africa	270	22.5
China	140	11.7
Mozambique	110	9.2
Senegal	70	5.8
Indonesia	55	4.6
USA	30	2.5
Kenya	30	2.5
World	**1,200**	**100.0**

e – preliminary values

Prices of traded commodities

Average annual zircon prices are based on DERA yearbook data and are given in USD/t. Average annual prices of unwrought zirconium and unwrought hafnium are based on MCS data and are given in USD/kg.

Commodity/year	2017	2018	2019	2020	2021
Zirkon, Standard, volně ložený, min. 65,5 % ZrO_2, CIF Čína, USD/t (DERA)	975.00	1,413.20	1,510.94	1,398.10	1,433.85
Zirkon, USD/t, FOB Austrálie (MCS)	975	N	N	N	N
Zirkon, USD/t, CIF Čína, (MCS)	1,295	1,625	1,585	1,415	1,780^{e}
Zirkonium surové, dovoz Čína do USA, USD/kg (MCS)	12	13	14	6	8^{e}
Hafnium surové, trh USA, USD/kg (MCS)	900	840	780	750	830^{e}

e – preliminary values

MINERALS UNMINED IN THE PAST WITHOUT RESOURCES AND RESERVES

INDUSTRIAL MINERALS

Andalusite, kyanite, sillimanite, mullite

1. Characteristics and use

Andalusite, kyanite (formerly also known as disthene) and sillimanite are mutually polymorphic minerals a $Al_2O_3.SiO_3$ chemism with a high Al content (50–63% Al_2O_3, but with different structures and different physical properties. Andalusite is a typical mineral of metamorphic rocks. Kyanite occurs mainly in crystalline shales (micaschists, gneisses) that are rich in aluminium, more rarely also on contacts, in granulites and eclogites. In some places, they also form independently extractable deposits of practical significance. Sillimanite occurs in metamorphites and also in pegmatites. At temperatures above 1,100 °C, $3Al_2O_3.2SiO_2$ mullite is formed from minerals of the sillimanite group by calcination.

Andalusite, originally from alluvium now from metapelites (from the Bushveld Complex), is mined in South Africa, from metaslates at the Glomel deposit in France, kyanite is mined from kyanite quartzites on Willis Mountain in the USA, kyanite is mined in Bhandara (India), in metasediments of the Kola Peninsula (Russia), sillimanite is mined mainly in India from alluvium (Odisha Sand Complex).

Reserves

They are extensive worldwide, but information are published only by India (688 kt of kyanite, 6,502 kt of sillimanite) (Indian minerals yearbook 2019). EU reserves of andalusite, sillimanite and kyanite have not been published. One of the largest is the French reserves of andalusite, also undisclosed.

Uses

All these minerals are valued mainly for their toughness, resistance to high temperatures, low expansion, excellent insulating properties and corrosion resistance. They are used for the production of special types of porcelain, lining of furnaces, etc. In the production of mullite during the cooling of the melt, elongated needle-like crystals are formed from small crystals, which penetrate the melt and strengthen the fired mass. Mullite provides a number of fire-resistant products (e.g. fireclay) with their most important technological properties. Its content increases heat resistance, heat absorption capacity, resistance to temperature changes, etc. Andalusite is preferred over kyanite because it can be used directly, without calcination and thus save energy.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have resources of andalusite, sillimanite and kyanite.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

250850 – Andalusite, kyanite and sillimanite

		2017	2018	2019	2020	2021
Import	t	4,920	5,667	5,326	7,406	8,504
Export	t	26	425	12	10	8

250850 – Andalusite, kyanite and sillimanite

		2017	2018	2019	2020	2021
Average import prices	CZK/t	10,372	10,705	12,063	12,557	12,099
Average export prices	CZK/t	29,081	11,717	29,625	31,753	30,663

250860 – Mullite

		2017	2018	2019	2020	2021
Import	t	572	1,764	2,031	1,014	2,587
Export	t	0,5	15	0,5	2	29

250860 – Mullite

		2017	2018	2019	2020	2021
Average import prices	CZK/t	15,564	15,496	11,348	14,567	14,311
Average export prices	CZK/t	133,332	18,743	109,453	27,742	23,669

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of kyanite and related minerals

Commodity/year	2017	2018	2019	2020	2021
World mine production of kyanite and related minerals (according to MCS), kt	N	N	N	N	N
World mine production of kyanite and related minerals (according to WBD), kt	N	N	N	N	N

Main producers of kyanite and related minerals according to MCS

Country*	2021^{e}	
	t	%
South Africa (andalusite)	180 000	N
India (kyanite and sillimanite)	69 000	N
USA (kyanite)	85 000	N
Peru (andalusite)	37 000	N
World total	**N**	**N**

e – estimate

* *In addition to the countries listed, France continued production of andalusite and Cameroon and China produced kyanite and related minerals. Output was not reported quantitatively, and no reliable basis was available for estimation of output levels.*

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021^e
Kyanite, average value exports, FAS, USD/t (MCS)	350	347	358	369	369
Andalusite, 57–58% Al_2O_3, FCA Mine, South Africa, 2,000 tonne bulk, EUR/t (IM)*	240–290	N	N	N	N
Andalusite, 55–59% Al_2O_3, FOB European port, EUR/t (IM)*	355–425	N	N	N	N
Andalusite, min 57% Al_2O_3, FOB South Africa, EUR/t (IM)*	N	260–320	270–340	260–340	N
Andalusite, min 57% Al_2O_3, CIF Europe, EUR/t (IM)*	N	390–430	320–450	320–440	N
Kyanite, 54–60% Al_2O_3, raw, U.S. ex-works, USD/t (IM)*	225–320	225–320	N	N	N
Kyanite, 54–60% Al_2O_3, calcinated, 22-ton lots, USD/t (IM)*	225–320	225–320	N	N	N

e – estimate

** Price range includes the lowest and the highest monthly price quotes for the given year.*

Asbestos

1. Characteristics and use

Asbestos is a technically usable mineral solid fibre of various mineralogical composition. The highest quality asbestoses are formed by flexible chrysotile fibres (chrysotile $Mg_3Si_2O_5(OH)_4$), less often amosite (amosite – mineralogically anthophyllite, grunerite or cummingtonite – $(Fe>Mg)_7Si_8O_{22}(OH)_2$ (grunerite formula) or by crocydolite $Na_2(Fe^{2+},Mg)_3Fe_2{}^{3+}Si_8O_{22}(OH)_2$. Brittle fibres tend to have an anthophyllite composition $(Mg,Fe^{2+})_7(Si_6O_{22})(OH,F)_2$. Less important are the amphibole asbestoses formed by tremolite $Ca_2Mg_5(Si_8O_{22}(OH,F)_2$ or actinolite $Ca_2(Mg,Fe^{2+})_5(Si_8O_{22}(OH,F)_2$.

Asbestos deposits are formed by hydrothermal processes associated with metamorphosis in ultrabasic rocks, dolomitic limestones or ferrous sedimentary formations. The most important deposits are found in mountain ranges of various ages. Typical examples are the Appalachian Mountains and the Rocky Mountains (USA, Canada) and the Ural (Russia).

The main types of deposits are

1. Stockwork mineralisations of asbestos in basic and ultrabasic rocks: Eastern Township (Canada), Thetford (Canada), Great Dyke (Zimbabwe), Shabani (Zimbabwe), Coalinga (USA), Paakkila(Finland), Val Malenco (Italy), Yanshan Region (China), Mangnai (China)
2. Deposits in metamorphic banded iron formations (BIF): Penge region (South Africa), Pomfret (South Africa), Asbest (Russia), Kiyembayevskoye (Russia)

Reserves

They are extensive worldwide, but unpublished. The EU does not have any asbestos reserves.

Uses

The properties that make asbestos universal and cost-effective are high ultimate tensile strength, chemical and thermal stability, high flexibility, low electrical conductivity and large surface area. The quality of asbestos is determined by the length of the fibres and their flexibility. The most expensive is the fibre asbestos, the lowest quality raw material is used in the production of asbestos-cement products. The use of asbestos has been limited for many years for health and environmental reasons (e.g. brake linings in the automotive industry).

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of asbestos.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2524 – Asbestos

		2017	2018	2019	2020	2021
Import	t	0.35	0.68	–	–	–
Export	t	0	0	–	–	–

2524 – Asbestos

		2017	2018	2019	2020	2021
Average import prices	CZK/t	362,857	123,529	–	–	–
Average export prices	CZK/t	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of asbestos

Commodity/year	2017	2018	2019	2020	2021^{e}
World mine production of asbestos (according to MCS), kt	1,170	1,150	1,170	1,100	1,200
World mine production of asbestos (according to WBD), kt	1,157	1,237	1,138	1,174	N

e – estimate

Main producers of asbestos according to MCS

Country*	2021^e	
	kt	%
Russia	700,000	58.3
Kazakhstan	250,000	20.8
China	120,000	10.0
Brazil	110,000	9.2
Zimbabwe	10,000	0.8
World total (rounded)	**1,200,000**	**100.0**

e – estimate

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021^e
Asbestos, price average U.S. customs value on import, USD/t (MCS)	1,870	1,670	1,570	2,110	2,000

e – estimate

Magnesite

1. Characteristics and use

Magnesite ($MgCO_3$) is the most important magnesium mineral (with a theoretical maximum content of 47.6% MgO). Magnesite deposits are bound to rocks rich in magnesium – dolomites and serpentinites. Magnesite and its deposits can be divided into crystalline and solid (cryptocrystalline) types:

1. Crystalline magnesite with grain dimensions below 10 mm: Eugui-Asturetta (Spain), Namdechon (North Korea), Liaoning (China), Breitenau (Austria), Dúbrava (Slovakia), Almora region (India), Savinsky District (Russia), Malchichinsky District (Russia), Mayardakskaya Region (Russia)
2. Solid magnesite with 0.004 to 0.01 mm grains and a conchoidal fracture resembling porcelain: Bushveld Complex (South Africa), Mantudi (Greece), Susehiri (Turkey), Bela Stena (Serbia), Kunwarara (Australia)

Crystalline magnesite is formed by the hydrothermal contribution of Mg to carbonate rocks, solid magnesite by the contribution of CO_2 to serpentinite. Solid magnesite can also have a sedimentary origin. Magnesite contains impurities of CaO, Fe_2O_3, MnO, Al_2O_3, SiO_2, etc., which affect the quality of the raw material. Magnesite is usually considered to be a raw material with a MgO content of at least 40% and a CaO content of at most 4%.

Reserves

2021		
Country	**kt MgO**	**% world**
Russia	2 300 000	30.3
China	1 000 000	13.2
Slovakia	370 000	4.9
Australia	320 000	4.2
Greece	280 000	3.7
Turkey	205 000	2.7
Brazil	200 000	2.6
India	82 000	1.1
Austria	49 000	0.6
Spain	35 000	0.5
USA	35 000	0.5
others	2,600,000	36.1%
World	**7,200,000**	**100.0**

Source: MCS 2022

2021			
Country	**kt MgO**	**% world**	**% EU**
EU	467,500	100.0	6.2
Slovakia	370,000	79.1	4.9
Austria	49,000	10.5	0.6
Spain	35,000	7.5	0.5
Poland* **	13,500	2.9	0.2

** own recalculation to MgO*
*** Bilans zasobów złóż kopalin w Polsce 2022*
Source: MCS 2022

Uses

Magnesite is mainly used for the production of caustic clinker, from which refractory materials and insulation are produced, and together with $MgCl_2$ also the Sorel cement for special floor materials, resistant to acids and oils. Other uses are in the chemical industry, in the production of paper and rayon.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of magnesite.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

251910 – Natural magnesium carbonate (magnesite)

		2017	2018	2019	2020	2021
Import	t	3,442	4,326	4,379	4,519	4,478
Export	t	15	3	4	1	4

251910 – Natural magnesium carbonate (magnesite)

		2017	2018	2019	2020	2021
Average import prices	CZK/t	1,993	1,996	2,604	2,386	2,482
Average export prices	CZK/t	9,761	51,387	94,529	444,166	769,815

251990 – Magnesia*, fused, dead-burned, other magnesium oxides

		2017	2018	2019	2020	2021
Import	t	56,133	66,676	59,814	57,375	54,600
Export	t	7,664	10,056	9,755	10,621	7,918

* *MgO*

251990 – Magnesia*, fused, dead-burned, other magnesium oxides

		2017	2018	2019	2020	2021
Average import prices	CZK/t	7,550	7,609	8,595	8,755	8,353
Average export prices	CZK/t	10,966	10,839	11,237	11,909	11,687

** MgO*

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of magnesite

Commodity/year	2017	2018	2019	2020	2021[e]
World mine production of magnesite (according to MCS), kt	29,100	27,100	27,100	27,000	30,000
World mine production of magnesite (according to WBD), kt	28,448	28,945	27,339	28,280	N

e – estimate

Main producers of magnesite according to MCS

Country	2021[e]	
	kt	%
China	21,000	70.0
Brazil	2,000	6.7
Turkey	1,600	5.3
Russia	1,100	3.7
Austria	870	2.9
Australia	770	2.6
Slovakia	530	1.8
Spain	720	2.4
Greece	550	1.8
other countries	1,000	3.3
World total (rounded)	**30,000**	**100.0**

e – estimate

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021e
Magnesite, Greek, raw, < 3.5% SiO_2, FOB East Mediterranean, USD/t (IM)*	65–80	70–80	70–80	70–80	N
Magnesite, calcinated, agricultural, CIF Europe, EUR/t (DERA)**	270.0	N	N	266.7	277.12
Magnesite, dead burned, 97.5% MgO, lump, FOB China, USD/t (DERA)**	465.6	N	N	404.6	458.96
Magnesite, fused, 98% MgO, lump, FOB China, USD/t (DERA)**	1,112.5	N	N	695.4	759.9

e – estimate
* *The price range includes the lowest and highest monthly price quotes in a given year.*
** *Average annual price.*

Perlite

1. Characteristics and use

Perlite is a natural volcanic glass (hyaloclastite) with a spherical texture, consisting of 65–78% SiO_2, mostly rhyolite, sometimes andesite. It is formed by the disintegration of lava pouring into water. Perlite deposits are found in many regions of the world. The world's most important producers include Greece, Turkey, the USA and Japan. Data from China are not known. Greece's global deposits lie in the Aegean Sea, on the islands of Kos and Milos.

Reserves

World reserves are extensive and published only rarely. EU perlite reserves are under-published. They occur in Greece and, among others, in Hungary and Slovakia (in Slovakia they are estimated at 30 million tons). European Minerals Yearbook - version 2021. Mineral resources of the Slovak Republic 2017.

Uses

By heating the perlite to a temperature of about 1000 °C, it expands rapidly to form a glassy foam, increasing the volume four to twenty times, so that the bulk density reaches values of 0.08 to 0.2 t/m^3. Expanded perlite is used in the construction industry for its thermal and sound insulation properties and for the production of aerated concrete, as well as in absorbent mixtures for the removal of oil stains on the water surface. The absorption properties of perlite are also used in the production of feed mixtures and bedding.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

Zásoby

2021		
Country	**kt**	**% world**
Greece	120,000	N
Iran	73,000	N
Turkey	57,000	N
USA	50,000	N
Hungary	49,000	N
World	**large**	**N**

Zdroj: MCS 2022

2. Mineral resources of the Czech Republic

The Czech Republic does not have any resources of perlite.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

25301010 – Perlite

		2017	2018	2019	2020	2021
Import	t	–	–	–	–	–
Export	t	–	–	–	–	–

25301010 – Perlite

		2017	2018	2019	2020	2021
Average import prices	CZK/t	–	–	–	–	–
Average export prices	CZK/t	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of perlite

Commodity/year	2017	2018	2019	2020	2021^{e}
World mine production of perlite (according to MCS), kt	4,650	4,020	3,460	4,220	4,200
World mine production of perlite (according to WBD), kt	2,376	2,714	2,823	3,015	N

e – estimate

Main producers of perlite according to MCS

Country	2021^e	
	kt	%
China	1,500	35.5
Turkey	1,200	28.4
Greece	710	16.8
United States*	500	11.8
Hungary	80	1.9
Iran	70	1.7
Armenia	50	1.2
Slovakia	30	0.7
New Zealand	20	0.5
Mexico	20	0.5
Argentina	20	0.5
other countries	30	0.7
World (rounded)	**4,200**	**100.0**

e – estimate
** Estimated production of crude ore*

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021^e
Perlite, average value, FOB mine in U.S., USD/t (MCS)	71	69	64	61	63
Perlite, raw, bulk, FOB Turkey, USD/t (IM)*	85–96	85–97	N	N	N
Perlite, coarse (filter aid), FOB east Mediterranean, EUR/t (IM)*	75–81	75–82	N	N	N
Perlite, raw, crushed, grated, big bags, FOB Turkey, USD/t (DERA)**	105.0	N	N	N	N

e – estimate
** Price range includes the lowest and the highest monthly price quotes for the given year*
*** Average annual price*

Rock salt

1. Characteristics and use

Rock salt (halite) is a sedimentary rock composed entirely or mainly of sodium chloride NaCl. It is usually formed by chemical sedimentation (evaporation) from true solutions. Three types of halite deposits can be distinguished (in solid state):

1. Salt pans in arid or semiarid environments (playas): Searles Lake (USA)
2. Layered deposits: Paradox Basin (USA), Zechstein Formation (Germany), Sergipe (Brazil)
3. Salt domes: Kłodawa (Poland), Zechstein Formation (Germany), Turda (Romania), Gulf Coast Region (USA)

The evaporite sedimentation hypotheses assume sedimentation in sabkhas i.e. either in muddy coastal plateaus lying just above sea level at high tide or in flat inland depressions in semiarid to arid areas, with aeolian sediments and various muds saturated with evaporating brine in sabkhas, as well as in deep-sea basins that have not dried up at all and were not salt basins.

Reserves

2021		
Country	**kt**	**% EU**
Poland	1,794,620	54.2
Slovakia	1,349,614	40.8
Italy	100,000	3.0
Spain	55,568	1.7
Romania	12,000	0.4
EU	**3,311,802**	**100.0**

Source: European Minerals Yearbook – version 2022

They are extensive and, including seawater, practically inexhaustible (MCS 2021).

Uses

Rock salt (salt) is used in the world mainly in the chemical industry for the production of chlorine, soda and some inorganic salts, in the food industry, as a preservative, for winter gritting material for roads and paths, as well as in the production of rubber and paints, in ceramics, and in agriculture.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any resources of rock salt.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2501 – Salt (inclusive table and denaturated salt), and pure sodium chloride; also in water solution

		2017	2018	2019	2020	2021
Import	t	671,717	564,468	674,275	399,323	698,482
Export	t	43,072	33,051	39,301	19,020	24,773

2501 – Salt (inclusive table and denaturated salt), and pure sodium chloride; also in water solution

		2017	2018	2019	2020	2021
Average import prices	CZK/t	1,791	1,839	1,756	2,221	1,907
Average export prices	CZK/t	5,539	6,150	5,752	12,550	9,146

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of salt

Commodity/year	2017	2018	2019	2020	2021[e]
World mine production of salt (according to MCS), kt	288,000	286,000	283,000	280,000	290,000
World mine production of salt (according to WBD), kt	282,716	291,703	290,609	269,953	N

e – estimate

Main producers of salt as estimated by MCS

Country	2021^{e}	
	kt	%
China	64,000	22.4
United States*	40,000	14.0
India	29,000	10.2
Germany	15,000	5.3
Australia	12,000	4.2
Canada	10,000	3.5
Chile	10,000	3.5
Mexico	9,000	3.2
Russia	8,000	2.8
Brazil	7,400	2.6
Turkey	6,900	2.4
Netherlands	6,200	2.2
France	5,400	1.9
United Kingdom	4,700	1.6
Spain	4,200	1.5
Poland	4,000	1.4
Pakistan	4,000	1.4
Djibouti	3,200	1.1
Saudi Arabia	2,700	0.9
Iran	2,600	0.9
Italy	2,000	0.7
Ukraine	2,000	0.7
other countries	33,000	11.6
World (rounded)	**290,000**	**100.0**

e – estimate
** Excluding Puerto Rico*

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021^{e}
Vacuum and open pan salt, USD/t (MCS)*	198	214	215	215	220
Solar salt, USD/t (MCS)*	116	121	125	120	120
Rock salt, USD/t (MCS)*	60	61	59	57	56
Salt in brine, USD/t (MCS)*	9,49	8,3	9,0	9,0	9,0

e – estimate
** U.S. price, average value of bulk, pellets and packaged salt, FOB mine and plant*

Talc

1. Characteristics and use

Talc is a soft, white when uncontaminated, scaly magnesium silicate – $Mg_3Si_4O_{10}(OH)_2$ with a melting point of 1,200 to 1,500 °C. Talc is formed by the contribution of SiO_2 and water to rocks rich in magnesium (dolomites, dolomitic limestones, magnesites, ultrabasics) in the hydrothermal stage and during regional metamorphosis. It is mined in Yellowstone (USA), Treasure (USA), Argonaut (USA), Madoc (Canada), Penhorwood Township (Canada), localities in Parana, Bahia, Sao Paulo and Minas Gerais states (Brazil), Lipasvaara (Finland), Trimouns (France), Rabenwald (Austria), localities in the regions of Leon and Malaga (Spain), Three Springs (Australia), and localities in the state of Rajasthan (India).

Reserves

2021		
Country	**kt**	**% world**
USA	140,000	23.2
India*	110,000	17.8
Japan*	100,000	16.7
China	82,000	13.7
South Korea*	81,000	13.5
Brazil	45,000	7.5
World	**> 600,000**	**100.0**

Source: MCS 2022

2021			
Country	**kt**	**% world**	**% EU**
EU	104,300	100.0	17.4
Slovakia	93,700	89.8	15.6
Italy	10,000	9.6	1.7
Spain	600	0.6	0.1

Source: European Minerals Yearbook – version 2022

Uses

A massive cryptocrystalline variety of talc with high electrical resistance, which is easy to work with, is called steatite. Rock mixtures of talc and magnesite with a frequent admixture of chlorites, called soapstone, have similar properties to talc. The quality of talc is reduced by all additives containing Fe^{3+}, pyrite and Mn oxides. The wide range of uses of talc is due to its properties, especially chemical resistance to acids and alkalis, low electrical and thermal conductivity, high absorption capacity for binding fats, oils and paints, perfect cleavage and in its high-quality varieties also pure white colour.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of talc.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2526 – Natural steatite; talc

		2017	2018	2019	2020	2021
Import	t	19,155	19,611	20,692	24,743	17,733
Export	t	388	428	385	294	594

2526 – Natural steatite; talc

		2017	2018	2019	2020	2021
Average import prices	CZK/t	8,144	8,074	7,681	5,951	8,032
Average export prices	CZK/t	19,568	23,674	17,638	18,934	10,026

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of talc and pyrophyllite

Commodity/year	2017	2018	2019	2020	2021[e]
World mine production of talc and pyrophyllite (according to MCS), kt	7,270	6,600	6,140	6,720	7,000
World mine production of talc and pyrophyllite (according to WBD), kt	7,479	7,886	8,100	7,644	N

e – estimate

Main producers of talc and pyrophyllite according to MCS

Country	2021^{e}	
	kt	%
India (incl. pyrophyllite)	1,700	24.3
China	1,400	20.0
Brazil (incl. pyrophyllite)	650	9.3
USA (crude)	490	7.0
France (crude)	450	6.4
Korea. Republic of (incl. pyrophyllite)	450	6.4
Finland	300	4.3
Canada (unspecified)	240	3.4
Italy (incl. steatite)	170	2.4
Japan	160	2.3
South Africa	130	1.9
Pakistan	120	1.7
other countries	700	10.0
World (rounded)	**7,000**	**100.0**

e – estimate

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021^{e}
Talc, average price, milled, ex-works, sold by U.S. producers, USD/t (MCS)	214	227	240	265	270

e – estimate

Raw materials for the production of industrial fertilisers

1. Characteristics and use

Raw materials for the production of industrial fertilisers, as well as the fertilisers themselves, are divided into nitrogen, phosphorus, potassium and combined. Besides these, this group also includes microelements necessary for the nutrition of organisms. These include: Ca, Mg, B, Cu, Fe, Mn, Mo and Zn. According to the Food and Agriculture Organisation, world demand for industrial fertilisers in 2019 was about 107 million tonnes of N, 47 million tonnes of P_2O_5 and 38 million tonnes of K_2O.

Natural nitrates are known as the Chile saltpeter containing $NaNO_3$, forming a 100 km long narrow strip of deposits in the Atacama Desert in Chile. The production capacity of Chile saltpeter reaches 1 million tonnes, while the world production capacity of synthetic NH_3 is around 190 million tonnes of N. The most widely used N-containing fertilisers are primary ammonium phosphate $(NH_4)_2H_2PO_4$ (also called ammonium dihydrogen phosphate), calcium amide $Ca(NH_2)_2$ and urea CH_4N_2O.

Natural sources of phosphorus are mainly based on the mineral apatite $Ca_5(F,OH,Cl)(PO_4)_3$ (circa 40% P_2O_5) and they can be divided into sedimentary and magmatogenic. They are of the greatest importance for the production of industrial fertilisers:

1. Sedimentary deposits in marine sediments (about 80% of world production): Phosphoria Formation (USA), Mount Isa area (Australia), Al Jalamid (Saudi Arabia), Oulad Abdoun (Morocco), Wengfu (China)
2. Magmatogenic deposits of apatites in alkaline igneous rocks (almost all remaining production): Chibiny (Russia), Palabora Complex (South Africa), Fanshan Complex (China), Siilinjärvi (Finland)

The source of potassium raw materials are almost exclusively the deposits of evaporites, occurring together with rock salt. From the point of view of chemistry, these evaporites are divided into deposits rich in Mg-sulphates, where the main minerals are carnallite $KMgCl_3.6H_2O$, polyhalite $K_2Ca_2Mg(SO_4)4.H_2O$ and epsomite $Mg(SO_4).7H_2O$, and Mg-poor deposits with the main minerals sylvite KCl and carnallite.

Uses

Raw materials for the production of industrial fertilisers have a wider use in the chemical industry, e.g. in pharmacy, production of compounds (e.g. nitric acid), they are used in the glass industry, metallurgy, cryogenic technology, photovoltaics.

Reserves

Phosphates

Country	2021	
	mill t	% world
Morocco and Western Sahara	50,000	70.4
China	3,200	4.5
Egypt	2,800	3.9
Algeria	2,200	3.1
Syria	1,800	2.5
Brazil	1,600	2.3
Saudi Arabia	1,400	2.0
South Africa	1,400	2.0
Australia	1,100	1.5
Finland	1,000	1.4
USA	1,000	1.4
Jordan	800	1.1
Kazakhstan	260	0.4
Peru	210	0.3
Tunis	100	0.1
Uzbekistan	100	0.1
Israel	57	0.1
Senegal	50	0.1
India	46	0.1
Mexico	30	0.0
Togo	30	0.0
Vietnam	30	0.0
World	**71,000**	**0.0**

Source: MCS 2021

EU phosphate reserves are not published. They occur in Spain and especially in Finland (European Minerals Yearbook – version 2021)

Potassium raw material

2021		
Country	**kt K_2O**	**% world**
Canada	1,100,000	29.7
Belorussia	750,000	20.3
Russia	600,000	16.2
China	350,000	9.5
USA	220,000	5.9
Germany	150,000	4.1
Chile	100,000	2.7
Laos	75,000	2.0
Spain	68,000	1.8
Brazil	2,300	0.1
World	**3,700,000**	**100.0**

Source: MCS 2022

2020			
Country	**kt K_2O**	**% svět**	**% EU**
EU	341 000	9.2	100.0
Německo	150 000	4.1	44.0
Polsko**	73 000	2.0	21.4
Španělsko	68 000	1.8	19.9
Itálie*	50 000	1.4	14.7

Source: MCS 2021. European Minerals Yearbook – version 2021
* own recalculation to K_2O*
*** Bilans zasobów złoż kopalin w Polsce 2021*

Nitrates

The reserves of nitrates (saltpeter) in Chile amount to 88,730 kt (Minerals Yearbook 2015) but they represent a negligible amount due to atmospheric nitrogen and natural gas which are used to produce N compounds. The EU does not have nitrate reserves.

Uses

Raw materials for the production of industrial fertilisers have a wider use in the chemical industry, e.g. in pharmacy, production of compounds (e.g. nitric acid), they are used in the glass industry, metallurgy, cryogenic technology, photovoltaics.

Classification as critical raw materials for the European Union

Nitrates: 2011 – no, 2014 – no, 2017 – no, 2020 – no
Potassium raw material: 2011 – no, 2014 – no, 2017 – no, 2020 – no
Phosphates: 2011 – no, 2014 – yes, 2017 – yes, 2020 – yes

2. Raw material resources of the Czech Republic

The Czech Republic does not have any sources of raw materials for the production of industrial fertilisers.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

3102 – Nitrogenous fertilizers

		2017	2018	2019	2020	2021
Import	t	914,871	872,766	527,060	872,714	797,617
Export	t	565,344	576,463	590,675	575,630	641,906

3102 – Nitrogenous fertilizers

		2017	2018	2019	2020	2021
Average import prices	CZK/t	4,873	4,914	4,772	4,936	7,805
Average export prices	CZK/t	4,379	4,434	4,913	4,462	5,781

2510 – Natural phosphates

		2017	2018	2019	2020	2021
Import	t	281	7	228	131	103
Export	t	20	13	13	49	1

2510 – Natural phosphates

		2017	2018	2019	2020	2021
Average import prices	CZK/t	13,824	326,742	18,833	23,836	39,929
Average export prices	CZK/t	2,094	2,723	3,517	3,185	178,612

2809 – Phosphoric oxides and acids

		2017	2018	2019	2020	2021
Import	t	6,531	6,200	6,129	6,219	6,321
Export	t	43,967	50,748	45,761	40,950	51,475

2809 – Phosphoric oxides and acids

		2017	2018	2019	2020	2021
Average import prices	CZK/t	8,213	9,066	9,719	7,741	9,712
Average export prices	CZK/t	17,896	19,042	19,578	18,630	19,873

3103 – Phosphatic fertilizers

		2017	2018	2019	2020	2021
Import	t	19,264	18,620	17,309	19,145	19,394
Export	t	221	154	87	859	337

3103 – Phosphatic fertilizers

		2017	2018	2019	2020	2021
Average import prices	CZK/t	6,982	7,598	7,855	7,110	8,505
Average export prices	CZK/t	11,263	18,609	30,091	8,200	15,682

3104 – Potassic fertilizers

		2017	2018	2019	2020	2021
Import	t	87,576	104,768	103,511	104,867	113,576
Export	t	6,115	7,342	4,589	4,682	5,679

3104 – Potassic fertilizers

		2017	2018	2019	2020	2021
Average import prices	CZK/t	7,890	7,583	8,165	7,916	7,989
Average export prices	CZK/t	25,550	20,920	29,465	34,393	28,223

3105 – Fertilizers containing several elements

		2017	2018	2019	2020	2021
Import	t	187,630	185,651	195,723	174,812	156,780
Export	t	15,408	18,885	28,403	28,834	47,015

3105 – Fertilizers containing several elements

		2017	2018	2019	2020	2021
Average import prices	CZK/t	9,028	9,224	9,584	9,290	11,646
Average export prices	CZK/t	14,861	11,670	7,944	10,914	8,131

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of phosphate rock and potash

Commodity/year	2017	2018	2019	2020	2021^e
World mine production of phosphate rock (according to MCS), kt	269,000	249,000	227,000	219,000	220,000
World mine production of phosphates (according to WBD), kt P_2O_5 content	79,600	71,631	70,987	70,064	N
World mine production of potash, K_2O equivalent (according to MCS), kt	41,400	43,300	41,300	44,000	46,000
World mine production of potash (according to WBD), kt K_2O content	42,322	43,476	42,082	44,996	N

e – estimate

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021^e
Marketable phosphate rock, avg. weighted value, FOB mine U.S., USD/t (MCS)	73.67	70.77	67.98	75.86	75.00
Phosphate, FOB Central Florida, USD/t (IM)*	475–500	N	N	N	N
Phosphate, 70–72% BPL**, long term contract, FAS Casablanca, Morocco, USD/t (IM)*	110–120	N	N	N	N
Phosphate rock, FOB North Africa, USD/t (DERA)	90	88	89	76	123.07
Potash, average all products, FOB mine USD/t K_2O, (MCS)***	770	750	820	850	980
Potash, average muriate, FOB mine and mill, USD/t K_2O, (MCS)	410	440	480	450	550
Potash, C&F Western Europe, contract, standard, USD/t (IM)*	310–390	N	N	N	N
Muriate, North America, USD/t (IM)*	310–340	N	N	N	N
Muriate, FOB Vancouver, USD/t (IM)*	300–390	N	N	N	N
Muriate, FOB Baltic, USD/t (IM)*	280–330	N	N	N	N

e – estimate

** Price range includes the lowest and the highest monthly price quotes for the given year.*

*** BPL – Bone Phosphate Lime $Ca_3(PO_4)_2$*

**** Includes MOP (muriate of potash – KCl), SOP (sulfate of potash – K_2SO_4) and SOPM (sulfate of potash magnesium – $K_2Mg_2(SO_4)_3$, $K_2Mg(SO_4)_2.4H_2O$). Does not include other chemical compounds that contain potassium.*

Main phosphate rock producers according to MCS

Country	2021^e	
	kt	%
China (large mines only)	85,000	39.1
Morocco	38,000	17.5
USA	22,000	10.1
Russia	14,000	6.4
Jordan	9,200	4.2
Saudi Arabia	8,500	3.9
Brazil	5,500	2.5
Egypt	5,000	2.3
Vietnam	4,700	2.2
Peru	3,800	1.7
Tunisia	3,200	1.5
Israel	3,000	1.4
Senegal	2,200	1.0
Australia	2,200	1.0
South Africa	2,000	0.9
Kazakhstan	1,500	0.7
India	1,400	0.6
Algeria	1,200	0.6
Togo	1,200	0.6
Finland	1,000	0.5
Uzbekistan	900	0.4
Turkey	600	0.3
Mexico	530	0.2
other countries	1,000	0.5
World (rounded)	**220,000**	**100.0**

e – estimate

Main potash producers according to MCS

Country	2021^e	
	kt	%
Canada	14,000	30.5
Russia	9,000	19.6
Belarus	8,000	17.4
China	6,000	13.1
Germany	2,300	5.0
Israel	2,300	5.0
Jordan	1,600	3.5
Chile	900	2.0
USA (rounded)	480	1.0
Spain	400	0.9
Laos	300	0.7
Brazil	210	0.5
other countries	370	0.8
World (rounded)	**46,000**	**100.0**

e – estimate

METALLIC ORES

Aluminium

1. Characteristics and use

Average Al content (and its extent) in the earth's crust (%)

8 (7.4–9) Al

Industrially important minerals

Bauxite ore is an impure mixture of Al minerals gibbsite $Al_2O_3.3H_2O$ (65% Al_2O_3), boehmite $Al_2O_3.H_2O$ (85% Al_2O_3) and diaspore $Al_2O_3.H_2O$ (85% Al_2O_3)

Industrially important deposit types

1. Bauxites from carbonate weathering – "terra rossa" type: Jamaica, Haiti, Dominican Republic, Hungary
2. Bauxites from lateritic weathering of various rocks containing Al: Guyana, Guinea, Suriname, Brazil, India, Ghana, Australia

Reserves

Bauxite

2021		
Country	kt	% world
Guinea	7,400,000	10,4
Vietnam	5,800,000	8,2
Austrálie	5,300,000	7,5
Brazílie	2,700,000	3,8
Indonésie	1,200,000	1,7
Čína	1,000,000	1,4
Indie	660,000	0,9
Rusko	500,000	0,7
Saudská Arábie	180,000	0,3
Kazachstán	160,000	0,2
USA	20,000	0,0
ostatní	5,100,000	7,2
svět	32,000,000	100,0
World	**30,000,000**	**100.0**

Source: MCS 2022

2021			
Country	kt	% world	% EU
EU	463,783	1.500	100.0
Greece	370,000	1.200	79.8
Hungary	79,783	0.300	17.2
Romania	13,000	0.040	2.8
Italy	1,000	0.003	0.2

European Minerals Yearbook – version 2022. Own calculations.

Uses

Some of the many uses of aluminium are in transport (cars, planes, trucks, railway vehicles, seagoing ships, etc.), packaging (cans, foils, etc.), construction (windows, doors, etc.), consumer durables (appliances, kitchen tools, etc.), power lines, machinery and many other applications. Aluminium hydroxide Al $(OH)_3$ is produced from bauxite by leaching with NaOH and its calcination produces alumina – aluminium oxide Al_2O_3. 90% of the produced alumina is a smelter feed for the production of aluminium. The remaining part is used for the production of refractory materials, ceramics, polishes and abrasive materials, paints, fillers for plastics and others.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any resources of aluminium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2606 – Aluminium ores and concentrates

		2017	2018	2019	2020	2021
Import	t	32,759	42,640	20,975	14,658	12,826
Export	t	0.2	103	0.3	16	45

2606 – Aluminium ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/t	3,533	3,518	4,834	5,153	6,710
Average export prices	CZK/t	745,856	14,821	746,032	72,019	13, 996

281820 – Aluminium oxide (other than synthetic corundum)

		2017	2018	2019	2020	2021
Import	t	14,111	15,969	19,465	19,984	24,430
Export	t	7,266	6,319	6,273	6,739	7,529

281820 – Aluminium oxide (other than synthetic corundum)

		2017	2018	2019	2020	2021
Average import prices	CZK/t	20,266	17,567	15,748	18,933	13,431
Average export prices	CZK/t	5,699	6,400	6,549	6,249	7,124

281830 – Aluminium hydroxide

		2017	2018	2019	2020	2021
Import	t	9,029	9,969	10,018	9,101	9,195
Export	t	133	26	6,273	31	33

281830 – Aluminium hydroxide

		2017	2018	2019	2020	2021
Average import prices	CZK/t	10,465	10,995	12,235	11,320	11,075
Average export prices	CZK/t	16,630	39,831	6,549	46,346	25,895

7601 – Raw (unwrought) aluminium

		2017	2018	2019	2020	2021
Import	t	51,786	51,877	46,238	45,723	57,382
Export	t	46,430	45,731	38,032	37,929	50,754

7601 – Raw (unwrought) aluminium

		2017	2018	2019	2020	2021
Average import prices	CZK/t	46,466	51,786	51,877	46,238	45,723
Average export prices	CZK/t	44,382	46,430	45,731	38,032	37,929

7602 – Aluminium waste and scrap

		2017	2018	2019	2020	2021
Import	t	115,096	119,634	124,700	122,686	116,463
Export	t	74,533	72,361	68,531	61,783	80,133

7602 – Aluminium waste and scrap

		2012	2017	2018	2019	2020
Average import prices	CZK/t	32,057	31,126	25,108	23,517	34,090
Average export prices	CZK/t	29,609	31,770	25,221	23,690	35,614

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of bauxite, production of alumina and aluminium*

Komodita/rok	2017	2018	2019	2020	2021^{e}
World mine production of bauxite (according to MCS), kt	309,000	327,000	358,000	391,000	390,000
World production of alumina (according to MCS), kt	129,000	131,000	133,000	136,000	140,000
World smelter production of aluminium (according to MCS), kt	59,400	63,600	63,200	65,100	68,000
World mine production of bauxite (according to WBD), kt	311,872	337,347	363,466	379,022	N
World smelter production of aluminium (according to WBD), kt	60,545	64,443	63,214	65,382	N

e – estimate

** As a general rule, 4 tons of dried bauxite is required to produce 2 tons of alumina, which, in turn, produces 1 ton of aluminium (MCS).*

Main producers of bauxite according to MCS – mine production

Country	2021e	
	kt	%
Australia	110,000	28.2
China	86,000	22.1
Guinea	85,000	21.8
Brazil	32,000	8.2
India	22,000	5.6
Indonesia	18,000	4.6
Russia	6,200	1.6
Jamaica	5,800	1.5
Kazakhstan	5,200	1.3
Saudi Arabia	4,300	1.1
Vietnam	3,500	0.9
other countries	12,000	3.1
United States	W*	N
World (rounded)	**390,000**	**100.0**

e – estimate
W – Witheld to avoid disclosing company proprietary data*

Main producers of aluminium according to MCS – smelter production

Country	2021e	
	kt	%
China	39,000	57.4
India	3,900	5.7
Russia	3,700	5.4
Canada	3,100	4.6
United Arab Emirates	2,600	3.8
Australia	1,600	2.4
Bahrain	1,500	2.2
Norway	1,400	2.1
USA	880	1.3
Iceland	880	1.3
Other countries	9,400	13.8
World (rounded)	**68,000**	**100.0**

e – estimate

Main producers of alumina according to MCS – refinery production

Country	2021e	
	kt*	%
China	74,000	54.7
Australia	21,000	15.5
Brazil	11,000	8.1
India	6,800	5.0
Russia	3,100	2.3
United Arab Emirates	2,000	1.5
Germany	1,900	1.4
Ireland	1,900	1.4
Saudi Arabia	1,800	1.3
Ukraine	1,700	1.3
Spain	1,600	1.2
Kazakhstan	1,500	1.1
Canada	1,500	1.1
Indonesia	1,500	1.1
Vietnam	1,400	1.0
Jamaica	1,200	0.9
United states	1,000	0.7
Guinea	400	0.3
other countries	3,000	2.2
World (rounded)	**140,000**	**100.0**

e – estimate
** Converted to Al_2O_3*

Prices of traded commodities

Komodita/rok	2017	2018	2019	2020	2021[e]
Bauxite, average value, U.S. imports FAS, USD/t (MCS)	31	31	32	26	32
Bauxite, refractory-grade 86%/2.0/3.15-3.2 (0-6 mm), FOB Xingang, China, USD/t (IM)*	280-480	430-480	390-450	390-435	N
Alumina, average value, U.S. imports FAS, USD/t (MCS)	486	592	480	412	450
Aluminium, ingot, avg. U.S. market (spot), cent/lb (MCS)	98.3	114.7	99.5	89.7	140
Aluminium, high grade primary, cash, in LME warehouse, USD/t (DERA)***	1,967.7	2,109.9	1,793.3	1,700.2	2,474.75
Aluminium, new scrap of aluminium alloy (Angel), EUR/100kg (DERA)***	135.2	146.2	128.0	108.9	170.06

e – estimate

* *Price range includes the lowest and the highest monthly price quotes for the given year.*

** *86/1.8/3.15 – 86% Al_2O_3, 1.8% Fe_2O_3, 3.15% SiO_2*

*** *Average annual price*

Beryllium

1. Characteristics and use

Average Be content (and its extent) in the earth's crust (ppm)

2.5 Be

Industrially important minerals

Beryl $Al_2Be_3Si_6O_{18}$ (14% BeO), bertrandite $Be(OH)_2Si_2O_7$ (15% BeO)

Industrially important deposit types

1. Pegmatite bodies, mostly with beryl, from which mainly beryl is obtained simultaneously with muscovite and with the minerals Ta and Li: Bernick Lake (Canada), Black Hills (USA), Bikita (Zimbabwe), Malakialina (Madagascar), Nerchinsk (Russia), Daran-Pich (Afghanistan), Travancore (India).
2. Extensive plutogenic, volcanogenic and metasomatic bodies consisting mostly of bertrandite, then phenakite, helvite, etc.: Sil Lake (Canada), Spor Mountain and Gold Hill (USA), Seward Peninsula (USA).

Reserves

World reserves are not listed. The EU does not have any beryllium reserves.

Uses

Despite its toxicity, beryllium is widely used in the nuclear, astronautic and aerospace industries, in the production of ballistic missiles and in the construction of submarines due to its exceptional physical properties. Alloys of beryllium with Cu, Zn, Pb and Sn are non-sparking and alloys with Al and Mg are part of the superlight materials family. The alloy of Be with Cu is highly sought after and it has the specific designation BCMA (beryllium-copper master alloy). Most of the world's metal and alloy production meets these needs.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of beryllium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

811212 – Unwrought beryllium, beryllium powders

		2017	2018	2019	2020	2021
Import	kg	–	–	–	–	–
Export	kg	–	1	–	–	–

811212 – Unwrought beryllium, beryllium powders

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	–	1,000	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of beryllium

Commodity/year	2017	2018	2019	2020	2021[e]
World mine production of beryllium content (according to MCS), t *	210	240	250	250	260
World mine production of beryllium (concentrates) (according to WBD), t	5,306	6,087	5,867	6,045	N

e – estimate

** Based on beryllium content 4% from bertrandite and beryl resources*

Main beryllium producers according to MCS

Based on beryllium content 4% from bertrandite and beryl resources

Country	2021[e]	
	t	%
United States	170	66.4
China	70	27.3
Uganda	7	2.7
Mozambique	3	1.2
Brazil	3	1.2
Madagascar	1	0.4
Nigeria	1	0.4
Rwanda	1	0.4
World (rounded)	**260**	**100.0**

e – estimate

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021[e]
Beryllium-copper master alloy, annual average U.S., USD/kg of contained beryllium (MCS)*	640	590	620	620	610

e – estimate

** Calculated from gross weight and customs value of imports; beryllium content estimated to be 4%. Rounded to two significant figures.*

Bismuth

1. Characteristics and use

Average Bi content (and its extent) in the earth's crust (ppm)

0.2 (0.1–1) Bi

Industrially important minerals

Native bismuth (100% Bi), bismutinite Bi_2S_3 (81% Bi)

Industrially important deposit types

Bismuth is obtained mainly from the processing of lead, tungsten, tin, copper and silver ores. Separate deposits of bismuth ores are mined in China and Bolivia.

1. Bismuth as a by-product: Deposits of lead ores, Bi-Co-Ni (U-Ag) five-element formations, copper ores, tungsten ores and Cu-Au ores: Adrasman (Cu-Bi, Kazakhstan), Salsigne (Au-Ag-Bi-As, France), Sangdong (W-Bi, South Korea), Xihuashan (W-Bi, China), Mt. Pleasant (W-Mo-Bi-Sn, Canada), Tennant Creek (Au-Bi-Cu, Australia), Bonfim (Brazil), Nui Phao (Vietnam).
2. Bismuth as a main metal: Deposits of different genetic types – Shizhuyuan (China), Tasna (Bolivia), Ustarasaj (Kazakhstan).

Reserves

Estimates of world bismuth reserves are not published. The EU does not have any bismuth reserves.

Uses

The most common use for bismuth is in easy-fusible alloys for the production of special solders, etc. The new zinc-bismuth alloy is used in galvanising. Bismuth is also used for the production of lubricants, especially for extreme pressures, as well as for the production of ceramic glazes, in the production of mountain crystal and pigments. The superconducting ceramics is made of Bi-Sr-Ca-Cu oxides. Bismuth compounds are used in the pharmaceutical industry and bismuth is also used as an additive in metallurgy. Bismuth is widely used as a non-toxic lead substitute.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – yes, 2020 – yes

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved sources of 49.8 t Bi in the Kutná Hora district, 34 t Bi in the Zlaté Hory district, 6,028 t Bi in the Cínovec area.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

81060010 – Unwrought bismuth, including waste and scrap, powders

		2017	2018	2019	2020	2021
Import	kg	95,674	102,695	67,090	73,542	82,226
Export	kg	1,228	361	154	61	3,259

81060010 – Unwrought bismuth, including waste and scrap, powders

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	249	223	163	136	172
Average export prices	CZK/kg	305	139	305	197	341

81060090 – Wrought bismuth, articles of bismuth, excluding unwrought bismuth, waste, scrap and powders

		2017	2018	2019	2020	2021
Import	kg	3,132	3,356	2,211	14,564	6,827
Export	kg	16,675	2,491	8,781	2,089	3,126

81060090 – Wrought bismuth, articles of bismuth, excluding unwrought bismuth, waste, scrap and powders

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	1,137	1,114	1,244	352	823
Average export prices	CZK/kg	184	1,154	477	1,232	1,173

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of Bismuth

Commodity/year	2017	2018	2019	2020	2021^{e}
World refinery production of bismuth (according to MCS), t gross weight	16,900	19,200	21,100	19,000	19,000
World mine production of bismuth (according to WBD), t	10,607	10,886	9,073	9,513	N

e – estimate

Main producers of bismuth according to MCS
Refinery production

Country	2021^{e}	
	t*	%
China	16,000	84.3
Laos	1,000	5.3
Korea, Republic of	1,000	5.3
Japan	600	3.2
Kazakhstan	240	1.3
Bolivia	60	0.3
Bulgaria	50	0.3
Canada	30	0.2
Mexico	10	0.1
World (rounded)	**19,000**	**100.0**

e – estimate

** Metric tons gross weight*

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021[e]
Bismuth, free market, USD/lb (MB)*	4.40-5.40	3.40-5.40	2.45-4.20	2.45-3.10	N
Bismuth metal, USD/lb (MCS)**	4.94	4.61	3.18	2.72	3.65
Bismuth metal, refined ≥ 99.99%, USD/kg (DERA)***	N	9,381.20	6,358.40	5,341.1	7,100.99
Bismuth metal, 99.99%, MB free market, 1t lots, in warehouse, USD/kg (DERA)***	10.9	N	N	N	N

e – estimate

* *Price range includes the lowest and the highest daily price quotes for the given year.*

** *Price in 2015 is based on New York dealer price for 99.99% – purity metal in minimum lots of 1 ton; source: Platts Metals Week. Prices in 2016–19 are based on 99.99% – purity metal at warehouse (Rotterdam) in minimum lots of 1 ton; source: American Metal Market (Fastmarkets AMM).*

*** *Average annual price*

Cadmium

1. Characteristics and use

Average Cd content (and its extent) in the earth's crust (ppm)

0.2 Cd

Industrially important minerals

Separate cadmium minerals, including the most abundant greenockite CdS (76% Cd), are industrially insignificant. Cadmium is an admixture in sulphides, especially in ZnS sphalerite (70–82 000 ppm Cd), chalcopyrite $CuFeS_2$ (30–1 200 ppm Cd), tetrahedrite $Cu_{12}Sb_4S_{13}$ (500–17 900 ppm Cd), bornite Cu_5FeS_4 (16–1 000 Cd) and bournonite $2PbS.Cu_2S.Sb_2S_3$ (50–100 ppm Cd).

Industrially important deposit types

Polymetallic and copper deposits. The Cd content of a typical Zn ore is on average 0.03% (300 ppm).

Reserves

World quantitative estimates are not available (MCS 2021).

According to data (Bilans zasobów złóż kopalin w Polsce 2020), the EU has Cd reserves in Poland. This is a 20 kt Cd.

Uses

Part of the Cd production is used for surface protection of metals against corrosion. However, it must not be used on food contact objects as it reacts easily with acids and soluble Cd compounds are highly toxic. Until recently, most Cd went to the production of Ni-Cd batteries and Cd-Ag and Hg-Cd electric cells (around 83%). However, their use is systematically limited because of environmental protection. A smaller part of Cd is used for the stabilisation of plastics, as well as for the production of pigments and in alloys for solders and fusible metals (e.g. Wood's metal). In the European Union, from 2006 onwards, various measures restricting the use of Cd in electrical engineering and electronics are gradually coming into force.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved cadmium sources in the amount of 1,013 t Cd in the Kutná Hora district and 2,500 t Cd in the Zlaté Hory district.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

810720 – Unwrought cadmium, cadmium powders

		2017	2018	2019	2020	2021
Import	kg	771	222	64	233	180
Export	kg	0	0	0	0	0

810720 – Unwrought cadmium, cadmium powders

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	361	883	703	983	1016
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of cadmium

Commodity/year	2017	2018	2019	2020	2021^{e}
World refinery cadmium metal production as a byproduct of zinc refining plus cadmium metal from recycling, except USA (according to MCS), t*	23,900	25,400	25,100	24,400	23,000
World mine production of cadmium, (according to WBD), t	26,341	26,781	24,465	23,697	N

e – estimate

** Cadmium content*

Main producers of cadmium according to MCS

Country	2021^e	
	t*	%
China	10,000	42.2
Korea, Republic of	3,000	12.7
Japan	1,900	8.0
Canada	1,800	7.6
Kazakhstan	1,500	6.3
Russia	1,000	4.2
Netherlands	900	3.8
Mexico	800	3.4
Peru	600	2.5
Germany	500	2.1
Norway	400	1.7
Uzbekistan	400	1.7
Australia	300	1.3
other countries	600	2.5
World (rounded)	**24,000**	**100.0**

e – estimate
** Cadmium content*

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021^e
Cadmium metal, annual average, dealer price for 99.95% purity in 5-short-ton lots*, USD/kg (MCS)	1.75	2.89	2.67	2.29	2.49
Cadmium, ingot, >= 99,99 % USD/t (DERA)**	N	N	N	N	2,654.88

e – estimate
** s.t. (short ton), 1 s.t. = 0,907185 metric ton*
*** Year average*

Chromium

1. Characteristics and use

Average Cr content (and its extent) in the earth's crust (ppm)

100 (20–2,700) Cr

Industrially important minerals

Chromite $(Fe,Mg)O(Cr,Al,Fe)_2O_3$ (45–55%, max.68% Cr_2O_3)

Industrially important deposit types

They are bound to ultrabasic and basic igneous rocks:

1. Stratiform (larger positions of ore concordant with magma structures): Bushveld (South Africa), Great Dyke (Zimbabwe), Stillwater complex (USA)
2. Podiform (ore lenses in ophthalite dunites): Kempirsay massif with deposits Almaz, Zhemchuzhina, Molodezhnoye, Millionnoye, etc. (Kazakhstan), Saranovskoye (Russia), deposits in Cuba, the Philippines and New Caledonia

Reserves

2021		
Country	**kt**	**% world**
Kazakhstan	230,000	40.4
South Africa	200,000	35.1
India	100,000	17.5
Turkey	26,000	4.6
Finland	13,000	2.3
USA	620	0.1
World	**570,000**	**100.0**

In the EU, only Finland has Cr reserves, namely 29 million tonnes of ore converted to 45% of Cr_2O_3 content, i.e. 5% of world Cr ore reserves converted to 45% of Cr_2O_3 content
Source: European Minerals Yearbook – version 2021.

Notes: ore is normalized to 45% Cr_2O_3 with the exception of Finland (26% Cr_2O_3) and the USA (7% Cr_2O_3)
Source: MCS 2022.

In the EU, only Finland has European reserves (European Minerals Yearbook – version 2021).

Uses

Chromium is an important alloying element in the steel industry, chromites are consumed for the production of refractory materials and slightly less for the needs of the chemical industry. From the point of view of industrial use, the division of chromite ores into metallurgical, chemical and fire-resistant raw materials is important. For metallurgy the minimum content of Cr_2O_3 is 48%, for the chemical industry it is at least 44% Cr_2O_3 and for the refractory industry 32% Cr_2O_3.

Classification as critical raw materials for the European Union

2011 – no, 2014 – yes, 2017 – no, 2020 – no

2. Raw material resources of the Czech Republic

The Czech Republic does not have any sources of chromium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2610 – Chromium ores and concentrates

		2017	2018	2019	2020	2021
Import	t	4,502	3,761	3,212	3,290	3,400
Export	t	569	656	255	348	578

2610 – Chromium ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/t	11,935	12,190	11,017	14,605	7,655
Average export prices	CZK/t	7,542	5,894	4,085	5,320	4,971

811221 – Unwrought chromium

		2017	2018	2019	2020	2021
Import	kg	0	91,654	107,946	113,761	228
Export	kg	0	239,493	220,327	150,315	54,034

811221 – Unwrought chromium

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	–	211	197	147	149
Average export prices	CZK/kg	–	52	57	36	74

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of chromium

Commodity/year	2017	2018	2019	2020	2021[e]
World mine production of chromite ore (according to MCS), kt*	35,700	43,100	44,800	37,000	40,000
World mine production of chromium (according to WBD), kt of Cr_2O_3 content	14,221	15,364	15,920	11,965	N

e – estimate

** Gross weight of marketable chromite ore*

Main producers of chromite ore according to MCS

Country	2021[e]	
	kt*	%
South Africa	18,000	43.5
Kazakhstan	7,000	16.9
Turkey	7,000	16.9
India	3,000	7.2
Finland	2,300	5.6
other countries	4,100	9.9
World (rounded)	**40,000**	**100.0**

e – estimate

** Gross weight of marketable chromite ore*

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021[e]
Chromite ore, gross weight, USD/t (MCS)	259	279	248	179	210
Ferrochromium, chromium content (excl. ferrochromium silicon), USD/t (MCS)	2,547	2,549	2,094	1,878	2,400
Chromium metal, gross weight, USD/t (MCS)	9,675	11,344	10,393	7,931	7,500
Chromium, free market, aluminothermic, min. 99%, USD/t (MB)*	7,475–8,300	7,700–13,995	6,000–10,400	5,285–6,400	N

e – estimate

** Price range includes the lowest and the highest daily price quotes for the given year.*

Gallium

1. Characteristics and use

Average Ga content (and its extent) in the earth's crust (ppm)

15 Ga

Industrially important minerals

Bauxites (10–140 ppm Ga), nepheline $Na_3K(Al_4Si_4O_{16})$ (20–40 ppm Ga), sodalite $Na_8(Al_6Si_6O_{24})Cl_2$ (70–500 ppm Ga), sphalerite ZnS

Industrially important deposit types

Gallium is obtained as a by-product in the processing of bauxite and Zn concentrates.

Reserves

World reserves are not available. The EU does not have any Ga reserves.

Uses

Most of Ga is used in the form of GaAs (Ga-arsenide) and GaN (Ga-nitride) in optoelectronics for the production of light emitting diodes, laser diodes, photodetectors and for the production of photovoltaic cells.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of gallium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

81129289 – Unwrought gallium, gallium powders

		2017	2018	2019	2020	2021
Import	kg	8	0	7	10	0
Export	kg	0	0	0	0	0

81129289 – Unwrought gallium, gallium powders

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	–	26,429	7,000	–	–
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of gallium

Commodity/year	2017	2018	2019	2020	2021[e]
World mine production of gallium, gallium content in mined ores (according to MCS), t	320	413	351	327	430
World mine production of gallium, gallium content in mined ores (according to WBD), t	310	323	374	304	N

e – estimate

Main producers of gallium according to MCS

Country	2021[e]	
	t*	%
China	420	97.7
Russia	5	1.2
Japan	3	0.7
Korea, Republic of	2	0.2
World (rounded)	**430**	**100.0**

e – estimate
** Metric tons of gallium content*

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021[e]
Gallium imports to U.S., high-purity, refined, USD/kg (MCS)*	477	508	573	596	570
Gallium imports to U.S., low-purity, primary, USD/kg e (MCS)**	124	185	153	163	200

e – estimate
** Estimate based on average values of U.S. imports for 99.9999%- 99.99999%-pure gallium.*
*** Estimate based on average values of U.S. imports for 99.99%-pure gallium.*

Indium

1. Characteristics and use

Average In content (and its extent) in the earth's crust (ppm)

0.1 In

Industrially important minerals

Particular practical importance is held by the indium contents in the form of solid solutions in ZnS sphalerite; the higher contents are characteristic for ferrous, black sphalerites.

Industrially important deposit types

Indium does not form its own deposits. It is an accompanying raw material for Zn, Pb, Cu and Sn ores. It is represented in the concentrates of these ores as follows (in ppm): Zn concentrates 2–800, Pb concentrates 1–10, Cu concentrates 0.5 – 100, Sn concentrates 10–124.

Reserves

Worldwide 15–50 kt In (The availability of indium. NREL. U.S. Department of Energy 2015) of which China 75%, Peru 3%, Russia 1%, Canada 1%. USA 1%. The EU has reserves in Ireland. By a rough estimate, these reserves represent at least 3 kt In, thus 6%–20% of its world reserves. Quantitative estimates of In reserves worldwide are not available (MCS 2021).

Uses

Indium is mainly used in electronics, where it forms fine coatings in liquid crystal displays and electroluminescent lamps. Semiconductor compounds of In are used in infrared detectors, high-speed transistors and high-performance photovoltaic devices. Other uses are mainly for solders and alloys.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved indium resources in the total amount of 228.3 t In, located mainly in the Kutná Hora district.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

81129281 – Unwrought indium, indium powders

		2017	2018	2019	2020	2021
Import	kg	13	0	0	5	42
Export	kg	2	0	0	0	0

81129281 – Unwrought indium, indium powders

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	8 846	–	–	16,600	9,000
Average export prices	CZK/kg	8 500	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of indium

Commodity/year	2017	2018	2019	2020	2021^{e}
World refinery production of indium (according to MCS), t	714	741	968	960	920
World mine production of indium (according to WBD), t	782	830	917	944	N

e – estimate

Main producers according to MCS

Refinery production

Country	2021^e	
	t	%
China	530	57.6
Korea, Republic of	200	21.7
Japan	60	6.5
Canada	60	6.5
France	35	3.8
Belgium	20	2.2
Peru	10	1.1
Russia	5	0.5
World (rounded)	**920**	**100.0**

e – estimate

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021^e
Indium, annual average, New York dealer, min. 99.99%, delivered duties paid U.S., USD/kg (MCS)	363	375	390	395	N
Indium, annual average, warehouse Rotterdam, min. 99.99%, duties unpaid, USD/kg (MCS)	206	285	182	161	220
Indium, 99,99%, USA, USD/kg (Investing.com)	205	281	177	158	210
Indium, USD/kg (DERA)*	236.67	272.08	176.00	155.38	221.58

e – estimate

** 2017 prices for ingots, min. 99.97%, free market, in warehouse, 2018 through 2021 prices for indium ≥ 99.99%. Average annual price.*

Magnesium

1. Characteristics and use

Average Mg content (and its extent) in the earth's crust (%)

2.3 Mg, in sea water 0.13 Mg

Industrially important minerals

Forsterite Mg_2SiO_4 (34% Mg), dolomite $CaMg(CO_3)_2$, brucite $Mg(OH)_2$ (41% Mg), magnesite $MgCO_3$ (28% Mg)

Industrially important deposit types

1. Brine deposits underground or on the surface: Manistee (Michigan, USA), Great Salt Lake (Utah, USA), Laguna del Rey (Mexico), Dead Sea (Israel)
2. Large bodies of dolomites, magnesite and brucite: Dashiqiao (China), Konya (Turkey), Satka (Ural), Euboea Island (Greece), Veitsch (Austria), Dúbrava (Slovakia)
3. Evaporite salt deposits: Stassfurt (Germany), Solikamsk (Russia)

Another source of metallic magnesium used is seawater.

Reserves

The world's reserves and resources of magnesium are practically unlimited and even renewable, especially due to its content in seawater.

Uses

Most magnesium compounds are consumed for the production of refractory materials (see the *Magnesite* chapter of this yearbook), otherwise there are various applications in agriculture, chemistry, construction and environmental care. Magnesium alloys with aluminium, zinc and manganese are characterised by high strength and low weight.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes

This classification is paradoxical with regard to what is stated above in the information on Mg reserves and what is known about magnesite reserves and mining in the EU. They are present in Austria, Greece, the Netherlands, Poland and Slovakia, as the annual extraction of these countries represents about 4 million tonnes of magnesite (European mineral statistics 2008–2012, British Geological Survey). However, it is based on the EU's total dependence on imports of metallic Mg (Study on the review of the list of critical raw materials, Critical Raw Materials Factsheets, European Commission, June 2017).

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of magnesium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

810411 – Unwrought magnesium, containing at least 99.8 % by weight of magnesium

		2017	2018	2019	2020	2021
Import	t	1,612	1,125	2,402	2,357	2,219
Export	t	166	25	1	96	20

810411 – Unwrought magnesium, containing at least 99.8 % by weight of magnesium

		2017	2018	2019	2020	2021
Average import prices	CZK/t	57,371	54,484	59,694	55,497	75,455
Average export prices	CZK/t	62,106	62,134	95,588	50,810	82,310

810419 – Unwrought magnesium, containing less than 99.8 % by weight of magnesium

		2017	2018	2019	2020	2021
Import	t	582	210	111	267	2,675
Export	t	7,151	7,467	7,016	6,437	11,520

810419 – Unwrought magnesium, containing less than 99.8 % by weight of magnesium

		2017	2018	2019	2020	2021
Average import prices	CZK/t	38,976	58,430	98,227	77,272	63,727
Average export prices	CZK/t	66,053	62,856	66,530	66,478	68,222

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of magnesium

Commodity/year	2017	2018	2019	2020	2021e
World primary production of magnesium metal (according to MCS), kt*	1,050	996	1,120	1,000	950

e – estimate

** Excluding U.S. production*

Main producers of magnesium metal according to MCS

Primary production

Country	2021e	
	kt	%
China	800	84.7
Russia	60	6.3
Israel	22	2.3
Kazakhstan	20	2.1
Brazil	18	1.9
Turkey	15	1.6
Ukraine	10	1.1
United States	W*	N
World (rounded)	**950**	**100**

e – estimate

W – Withheld to avoid disclosing company proprietary data*

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021e
Magnesium, USD/t (DERA)*	2,258.8	2,502.5	2,320.6	1,987.1	4,030.73
Magnesium metal, U.S. spot Western, USD/lb (Platts Metal Week/MCS)	2.15	2.17	2.45	2.49	3.90
Magnesium metal, China, FOB, USD/t (Platts Metal Week/MCS)	2,265	2,550	2,425	2,149	5,500
Magnesium, European free market, USD/t (MB)**	2,050–2,855	2,300–2,800	2,150–2,800	2,150–2,400	N

e – estimate

** 2017 prices are for magnesium, min. 99.8%, MB free market, in warehouse, USD/t, 2018 through 2021 prices are for magnesium >=99.9% (Shanxi) USD/t. Average annual price.*

*** Price range includes the lowest and the highest daily price quotes for the given year*

Thallium

1. Characteristics and use

Average Tl content (and its extent) in the earth's crust (ppm)

1.2 (0.8–1.26) Tl

Industrially important minerals

Thallium does not have industrially important minerals, it is obtained during the processing of sulphide ores.

Industrially important deposit types

Thallium does not form separate deposits, it is a by-product of polymetallic and Au-Ag ores.

Reserves

World reserves of thallium are not reported. MCS 2020 estimates the world's resources of Tl in Zn ores at 17 kt Tl, mainly in Canada, Europe and the USA. Globally, there is 630 kt of thallium in coal. The EU does not list its Tl reserves (European Minerals Yearbook – version 2021). Poland is an exception with reserves of 150 t of thallium (Bilans zasobów złoż kopalin w Polsce 2021).

Uses

Thallium is obtained by processing fly ash and residues from the compaction of copper, zinc and lead ores. Thallium and its compounds are highly toxic substances. The radioactive isotope 201 is used in medicine to monitor cardiovascular diseases. Tl is also a detector in scintillometer; T1-Ba-Ca and Cu oxides form high temperature superconductors; Tl + As + Se crystals are part of acoustic-optical measuring devices; Tl in an alloy with Hg is used to measure low temperatures. Furthermore, Tl is added to glasses to increase their reflective properties and density, it is used as a catalyst in organic synthesis and for the preparation of high density fluids used in the separation of minerals of different weights.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of thallium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

811251 – Unwrought thallium

		2017	2018	2019	2020	2021
Import	kg	0	0	0	0	0
Export	kg	0	0	0	0	0

811251 – Unwrought thallium

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of thallium

Commodity/year	2017	2018	2019	2020	2021[e]
World refinery production of thallium (according to MCS), kg	< 9,000	< 9,000	< 8,000	< 8,000	~ 10,000

e – estimate

Main producers of thallium according to MCS

Refinery production

Country*	2021^{e}	
	kg	%
China	N	N
Kazakhstan	N	N
Russia	N	N
Brazil	N	N
North Macedonia	N	N
World	**~ 10,000**	**100.0**

e – estimate

** Estimated leading producers according to MCS*

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021^{e}
Thallium metal, 99.99%, granules in 100 gram lots (MCS)	N	N	7,600	8,200	8,400

e – estimate

Thorium

1. Characteristics and use

Average Th content (and its extent) in the earth's crust (ppm)

15 (0.1–18) Th

Industrially important minerals

Uranothorite (U,Th)SiO_4 (1–25% ThO_2), thorite $ThSiO_4$, thorianite $(Th,U)O_2$ (1–25% ThO_2), monazite $(Ce,Th)PO_4$ (25% ThO_2), zirkelite $(Ca,Th,Ce)Zr(Ti,Nb)_2O_7$ (6% Th)

Industrially important deposit types

1. Monazite placers in recent and buried offshore sediments in Australia, Egypt, India, South Africa, Malaysia, Powderhorn (USA)
2. Monazite deposits in primary ores, most often in pegmatites: (e.g. Nellur, Travancore, India, South Dakota – USA, Brazil, China), but also in carbonatites (e.g. Oka – Canada) or in uranium ores (e.g. Sunnyside Inglewood – Australia). Also included are thorianite (Madagascar, Sri Lanka), thorite (e.g. Bancroft – Canada) and zirkelite ores (e.g. Jacupiranga – Brazil).

Reserves

Worldwide 1,200 kt Th, of which Australia 25%, India 24%, Norway 14%, USA 13%, Canada 8% (World thorium occurrences, deposits and resources – IAEA 2019). EU reserves of 224 kt of thorium represent 19% of global reserves; Norway has 76% of EU reserves (= 14% of world reserves); according to the World thorium occurrences, deposits and resources – IAEA 2019 total thorium resources in the EU are around 284–291 kt Th and thus represent 4%–5% of world's Th sources.

Uses

In a magnesium alloy, thorium forms a high-strength and heat-resistant metal. Thorium is prospectively considered as a reserve fuel in nuclear reactors. Besides the energy industry, thorium in various forms is used in demanding ceramic production, for catalytic properties and in welding electrodes.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of thorium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

28443061 – Thorium bars, rods, angles, shapes, sections, wire, sheets, strips

		2017	2018	2019	2020	2021
Import	kg	0	0	0	0	0
Export	kg	0	0	0	0	0

28443061 – Thorium bars, rods, angles, shapes, sections, wire, sheets, strips

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	–	–	–	–	–

28443069 – Thorium other, not crude, waste, scrap, bars, rods, shapes, wire, sheets

		2017	2018	2019	2020	2021
Import	kg	0	0	0	0	0
Export	kg	0	0	0	0	0

28443069 – Thorium other, not crude, waste, scrap, bars, rods, shapes, wire, sheets

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	–	–	–	–	–

28443099 – Thorium salts

		2017	2018	2019	2020	2021
Import	kg	0	0	0	0	0
Export	kg	0	0	0	0	0

28443099 – Thorium salts

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of thorium

Commodity/year	2017	2018	2019	2020	2021
World refinery production of thorium (according to MCS), kg*	N	N	N	N	N

** Associated with recovery of monazite in REE heavy-mineral-sand deposits.*

Main producers of thorium

Country*	2021^e	
	kt	%
N	N	N
World total	**N**	**N**

e – estimate

** Associated with recovery of monazite in REE heavy-mineral-sand deposits.*

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021
Thorium compounds, gross weight, India, USD/kg (MCS)	73	72	72	N	N

Titanium

1. Characteristics and use

Average Ti content (and its extent) in the earth's crust (%)

0.5 (0.24–0.96) Ti

Industrially important minerals

Rutile TiO_2 (over 95% TiO_2), anatase (over 95% TiO_2), ilmenite $FeTiO_3$ (52 (35–70))% TiO_2

Industrially important deposit types

1. Deposits of titanomagnetites in basic rocks and titanite in apatite: Gusevogorsk (Russia), Chibiny (Russia), Damiao (China), Allard Lake (Canada), Powderhorn (USA), Campo Formosa (Brazil), Magnet Hill (JAR).
2. Ilmenite, rutile and zirconium placer deposits in recent and buried offshore sediments and weathered rocks: Irshinskoye (Russia), Murray Basin (Australia), Truro (Canada), Florida, Corridor Sands, Moma (Mozambique), Sierra Rutile (Sierra Leone), Fort Dauphin (Madagascar), locations in South Africa, India, New Zealand.

Reserves

Ilmenite

2021		
Country	**kt TiO_2**	**%**
China	230,000	32.9
Australia	160,000	22.9
India	85,000	12.1
Brazil	43,000	6.1
Norway	37,000	5.3
Canada	31,000	4.4
Mozambique	26,000	3.7
Madagascar	22,000	3.1
Ukraine	5,900	0.8
USA	2,000	0.3
Vietnam	390	0.1
Other	26,000	3.7
World	**700,000**	**100.0**

Note: TiO_2 content in ores
Source: MCS 2022

2021			
Country	**kt TiO_2**	**% world**	**% EU**
EU	133,972	100.0	18.0
Poland*	97,700	72.9	13.1
Norway	36,068	26.9	4.8
Slovakia	204	0.2	0.03

Source: European Minerals Yearbook – version 2021
** Bilans zasobów złóż kopalin w Polsce 2021*

Rutile

2021		
Country	**kt TiO_2**	**% world**
Australia	31,000	63.3
India	7,400	15.1
South Africa	6,500	13.3
Ukraine	2,500	5.1
Mozambique	890	1.8
Sierra Leone	490	1.0
Madagascar	400	0.8
Kenia	170	0.3
World	**49,000**	**100.0**

Zdroj: European Minerals Yearbook – version 2022

Uses

Astronautic and aerospace industries (alloys). TiO_2 is mainly used for the production of titanium white; it is also consumed for the plating of welding electrodes and in the production of titanovanadium, carbide, chemicals and metal.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any resources of titanium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2614 – Titanium ores and concentrates

		2017	2018	2019	2020	2021
Import	t	132,791	107,438	138,646	121,706	97,132
Export	t	796	861	780	581	624

2614 – Titanium ores and concentrates

		2017	2018	2019	2020	2021
Average import prices	CZK/t	4,920	5,674	6,081	6,119	6,186
Average export prices	CZK/t	23,018	23,900	27,606	32,021	33,482

8108 – Titanium and products of it, including waste and scrap

		2017	2018	2019	2020	2021
Import	t	2,713	2,747	3,450	2,773	1,687
Export	t	1,462	1,612	2,112	1,592	1,412

8108 – Titanium and products of it, including waste and scrap

		2017	2018	2019	2020	2021
Average import prices	CZK/t	507,122	478,419	433,156	436,724	539,649
Average export prices	CZK/t	365,200	365,125	349,408	381,562	378,851

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of titanium

Commodity/year	2017	2018	2019	2020	2021^e
World mine production of ilmenite concentrate (according to MCS), kt of TiO_2 content	5,540	6,870	7,700	8,000	8,400
World mine production of rutile concentrate (according to MCS), kt of TiO_2 content	770	594	654	605	630
World mine production of titanium (according to WBD), kt of TiO_2 content	7,120	7,549	7,907	8,424	N

e – estimate

Main producers of ilmenite according to MCS

Country	2021^e	
	kt*	%
China	3,000	35.7
South Africa**	1,000	11.9
Mozambique	970	11.5
Canada*	600	7.1
Australia	480	5.7
Norway	440	5.2
Ukraine	430	5.1
Senegal	360	4.3
Madagascar**	310	3.7
Vietnam	220	2.6
Kenya	190	2.3
India	180	2.1
United States***	100	1.2
Brazil	66	0.8
other countries	67	0.8
World (rounded)	**8,400**	**100.0**

e – estimate
** Metric tons of titanium content in mined concentrate*
*** Mine production is primarily used to produce titaniferous slag*
**** Including rutile, rounded to the nearest 100,000 tons*

Main producers of rutile according to MCS

Country	2021^e	
	kt*	%
Australia	200	31.8
Sierra Leone	120	19.1
South Africa	90	14.3
Ukraine	95	15.1
Kenya	71	11.3
India	11	1.7
Madagascar	10	1.6
Senegal	10	1.6
Mozambique	9	1.4
USA**	N	N
other countries	13	2.1
World (rounded)	**630**	**100.0**

e – estimate
** Metric tons of titanium content in mined concentrate*
*** Rutile content included in ilmenite production*

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021[e]
Rutile, bulk, min. 95% TiO_2, FOB Australia, USD/t (IM in MCS)*	740	1,025	1,125	1,175	1,500
Ilmenite, bulk, minimum 54% TiO_2, FOB Australia, USD/t (IM in MCS)*	393	420	504	460	640
Ilmenite, U.S. import, USD/t (MCS)	173	219	186	215	240
Slag, 80%–95% TiO_2, duty-paid U.S. import, USD/t (MCS)	664	738	792	757	750
Titanium ore concentrate, bulk, 95% TiO_2, USD/t (MB)**	710–770	710–1,100	1,000–1,200	1,100–1,200	N
Titanium ore concentrate, bulk, 54% TiO_2, USD/t (MB)**	100–185	160–200	164–220	190–230	N
Leucoxene, min. 91% TiO_2, max. 1% ZrO_2, bagged, FOB W. Australia, USD/t (IM)***	700–801	700–802	N	N	N
Rutile, concentrate, min. 95% TiO_2, bulk, CIF China, USD/t (IM)***	650–950	850–1,100	1,150–1,250	1,200–1,250	N
Ferrotitanium, USD/kg (DERA)****	4.8	4.9	5.0	4.33	7.42
Titanium, oxide, pigment, bulk volume, CIF Northern Europe, EUR/t (DERA)*****	2,712.3	N	N	2,908	3,271

e – estimate

* *Average of yearend price. Prices of ilmenite from Australia were discontinued at yearend 2017*

** *Price range includes the lowest and the highest daily price quotes for the given year.*

*** *Price range includes the lowest and the highest monthly price quotes for the given year.*

**** *2017 prices for ferrotitanium, basis 70% Ti, max. 4.5% Al, delivered European consumers' work, 2018 through 2021 prices for ferrotitanium 60%, FOB Europe. Average annual price.*

***** *Average annual price*

Vanadium

1. Characteristics and use

Average V content (and its extent) in the earth's crust (ppm)

150 (53–200) V

Industrially important minerals

Coulsonite FeV_2O_4 (variable contents of V_2O_5), montroseite (V,Fe)O(OH) (variable contents of V_2O_5), carnotite $K_2(UO_2)_2(VO_4)_2.3H_2O$ (20% V_2O_5), tjujamunite $Ca(UO_2)_2(VO_4)_2.5–8H_2O$ (20% V_2O_5)

Industrially important deposit types

1. Deposits of titanium magnetite ores with increased contents of Ti, V and sometimes also platinoids: Katchkanar (Ural), Lac Dore (Chibougamau District, Canada), Bushveld Massif (South Africa), Otanmäki (Finland), Panzhihua (China), Balla Balla (Australia).
2. Deposits of black shale and bituminous shale and sand with increased V or U content: Kafferskraal (South Africa), Grants, Lisbon Valley, Uravan (USA), Athabasca (Alberta, Kanada), Minas Ragra (Peru).

Reserves

2021		
Country	**kt**	**% world**
China	9,500	19.4
Australia	6,000	12.2
Russia	5,000	10.2
South Africa	3,500	7.1
Brazil	120	0.2
USA	45	0.1
World	**24,000**	**100.0**

Source: MCS 2021, own estimate

The EU does not have vanadium reserves (European Minerals Yearbook – version 2022).

Uses

Vanadium is an important alloying element in iron metallurgy, most often supplied in the form of ferrovanadium. 80 to 90% of vanadium is consumed by metallurgy. In the chemical industry, V is used as a catalyst in the cracking of crude oil and in the production of certain acids, paints and in rubber processing.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – yes, 2020 – yes

2. Mineral resources of the Czech Republic

The Czech Republic does not have any resources of vanadium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

81129291 – Unwrought vanadium, vanadium powders, excluding waste and scrap

		2017	2018	2019	2020	2021
Import	kg	29	329	168	163	472
Export	kg	1	27	19	4	128

81129291 – Unwrought vanadium, vanadium powders, excluding waste and scrap

		2017	2018	2019	2020	2021
Average import prices	CZK/kg	4,724	1,228	5,452	4,239	4,025
Average export prices	CZK/kg	1,000	1,037	20,053	25,250	37,547

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2021

There are none.

8. World production and world market prices

World mine production of vanadium

Commodity/year	2017	2018	2019	2020	2021e
World mine production of vanadium (according to MCS), t of vanadium content	71,200	71,200	73,000	105,000	110,000
World mine production of vanadium (according to WBD), t of vanadium content	81,892	84,947	98,723	105,776	N

e – estimate

Main producers of vanadium according to MCS

Mine production

Country	2021e	
	kt*	%
China	73,000	67.7
Russia	19,000	17.6
South Africa	9,100	8.4
Brazil**	6,700	6.2
USA	0	0
World (rounded)	**110,000**	**100.0**

e – estimate

** Thousand of metric tons of vanadium content*

*** Revised based on Government reports*

Prices of traded commodities

Commodity/year	2017	2018	2019	2020	2021e
Vanadium pentoxide (V_2O_5), min. 98%, Europe, USD/lb (MB)	4.80–1.25	9.60–29.15	4.45–17.75	4.80–7.75	N
Vanadium pentoxide (V_2O_5), USD/lb (MCS)*	7.61	16.4	12.2	6.7	8.2
Ferrovanadium, basis 70–80%, USD/kg (MB)**	45.00–49.50	43.25–140.00	27.00–76.00	26.00–31.00	N
Ferrovanadium, USD/kg (DERA)***	32.6	80.0	41.9	25.0	34.27

e – estimate

** The 2017 annual average vanadium pentoxide price includes U.S. monthly averages for January 2017–June 2017 and China monthly average prices for July 2017–December 2017. The prices for 2018–2021 are the China annual average vanadium pentoxide prices.*

*** Price range includes the lowest and the highest daily price quotes for the given year.*

**** Prices for ferrovanadium for 2017 are basis min. 78%, free delivered duty paid, consumer plant, 1st grade Western Europe. Prices for 2018 through 2021 are for ferrovanadium, 70–80%, CIF Europe. Average annual price*

MINERAL COMMODITY SUMMARIES
OF THE CZECH REPUBLIC

2021 Yearbook

Published by the Czech Geological Survey
Prague 2022
Klárov 131/3, 118 21 Praha 1
First edition, 494 pages
03/9 446-402-23

ISSN 1801-6707
ISBN 978-80-7673-075-5

The publication was supported by the financial contribution
from the Ministry of the Environment of the Czech Republic